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SYSTEM ENGINEERING ANALYSIS OF 600 PSI BOILERS INSTALLED ON AFS--ETC(U)
APR 82 C E WILSON, C P BEYERS   N00189-81-D-0126
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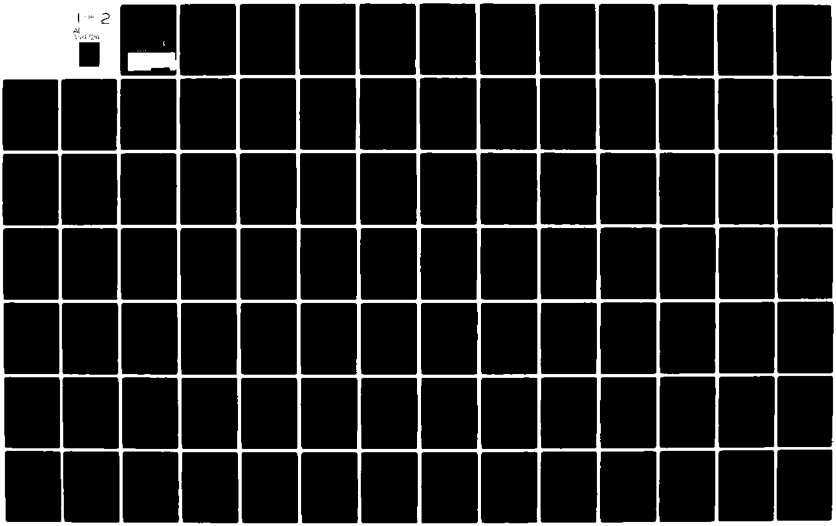

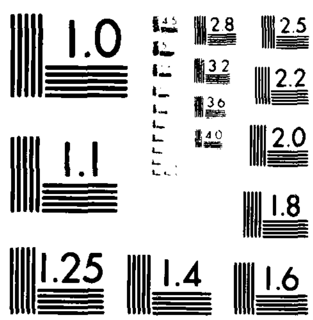

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SYSTEM ENGINEERING ANALYSIS OF 600 PSI BOILERS INSTALLED ON AFS-1, AOE-1, AOR-1, AND AO-177 CLASS SHIPS

April 1982

Prepared for
PLANNING AND ENGINEERING FOR REPAIRS AND ALTERATIONS
COMBAT SUPPORT SHIPS
HUNTERS POINT NAVAL SHIPYARD
SAN FRANCISCO, CALIFORNIA
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This report documents the historical maintenance experience for the 600 psi propulsion boiler system (ship's work authorization boundary [SWAB] 221-1), the boiler blow system (SWAB 221-2), & the boiler steam escape system (SWAB 221-4) installed on AFS-1, AOE-1, AOR-k, and AO-1 Class ships. It presents an analysis of the existing maintenance policy & recommends maintenance actions & policy modifications to improve system material condition.

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FOREWORD

This report documents the historical maintenance experience for the 600 psi propulsion boiler system (ship's work authorization boundary [SWAB] 221-1), the boiler blow system (SWAB 221-3), and the boiler steam escape system (SWAB 221-4) installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships. It presents an analysis of the existing maintenance policy and recommends specific maintenance actions and maintenance policy modifications to improve system material condition.

SUMMARY

The goal of an engineered operating cycle (EOC) program is to effect an early improvement in the material condition of ships at an acceptable cost, while maintaining or increasing their operational availability during an extended operating cycle. In support of this goal, system engineering analyses (SEAs) are being conducted for various ship classes on selected mission-critical systems and subsystems that have historically exhibited relatively high maintenance burdens. This report documents the SEA for the 600 psi propulsion boiler systems, boiler blow systems, and boiler steam escape systems, SWABs 221-1, 221-3, and 221-4, respectively, installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships.

The report on this SEA was originally submitted in June 1981 as ARINC Research Publication 2614-11-3-2485. That publication is superseded by this submission, which presents data and recommendations applicable to AO-177 Class boilers. It also includes data and comments resulting from the Navy's review of the original report. Comments were received from NAVSEA 522 and NAVSSES 022E; where necessary, ARINC Research incorporated revisions or additions to address those comments.

The SEA is an analysis of the impact of historical preventive and corrective maintenance requirements that affect operational performance and maintenance programs of a ship system and the significance of these requirements to an EOC Program. The report documents a recommended system maintenance policy and specific maintenance actions best suited to meeting EOC goals.

The SEA included an examination of all available maintenance data sources. The documented maintenance experience of each separate system configuration was identified by review and analysis of data from the maintenance data system (MDS), casualty reports (CASREPs), past ship alteration and repair packages (SARPs), post-overhaul analysis reports (POARs), and Destroyer Engineered Operating Cycle (DDEOC) Program system maintenance analyses (SMAs) previously conducted for functionally similar systems and equipments installed on DDEOC Program ships. Initial findings from these sources were correlated with current planned maintenance system (PMS) requirements, existing and planned system alterations, and system technical manual data. Discussions were held with operating personnel and appropriate technical personnel in NAVSEA to the extent necessary to validate identified maintenance requirements, to define undocumented maintenance requirements, and to determine the status of current and planned

actions affecting each system design. All findings were evaluated, and appropriate conclusions were developed.

On the basis of these conclusions, a recommended system maintenance policy was defined, and recommendations were made to implement the policy by periodically scheduling specific types of maintenance actions designed either to identify the need for specific corrective or restorative maintenanace or to perform such maintenance identified by the analysis as being required on a periodic basis. When considered appropriate on the basis of the analysis, recommendations were also made for improving system preventive maintenance; integrated logistic support; reliability, maintainability, and availability; and depot and intermediate maintenance activity (IMA) capabilities. Implementation of these combined recommendations will minimize the adverse impact of corrective and restorative maintenance requirements on an engineered operating cycle.

A total of five major conclusions and 40 separate technical and maintenance strategy recommendations resulted from this SEA for AFS-1, AOE-1, AOR-1, and AO-177 Class 600 psi propulsion boilers, boiler blow systems, and boiler steam escape systems. The conclusions and major recommendation are summarized as follows:

- Conclusions
  - Boilers, in general, do not wear out in the commonly accepted sense, because they have no moving parts. However, they do deteriorate over time as a result of corrosion, thermal stress, failure of support equipments, and damage attributable to personnel operating errors.
  - The principal factor limiting the interval at which boilers should be overhauled by an industrial facility is the total replacement of brick refractory. With the exception of catastrophic failures resulting from damage due to multiple tube ruptures or major flareback, brick refractory should perform reliably, with only minor ship's force or IMA-level repairs, for up to 10 years.
  - Boilers and boiler accessory equipments have traditionally been subjected to major industrial-level repairs in conjunction with ship overhauls at intervals ranging from three and one-half to five years. However, there is no evidence from this SEA to support the need for performing industrial-level boiler overhauls at intervals of less than 10 years.
  - During the operating cycle (between boiler overhauls), boilers and boiler accessory equipments are maintained according to the following maintenance strategies:
    - Boilers are maintained under an on-condition maintenance strategy. Necessary repairs are identified through periodic boiler inspections specified by PMS and OPNAV Instruction 9221.1. All operating cycle repairs are normally accomplished by ship's force personnel, assisted as necessary by an IMA or outside contractors.

-- Boiler accessory equipments (fuel oil burners, safety valves, soot blower heads and elements, gage glasses, smoke indicators, and bottom blow and general-purpose steam valves) are currently maintained under a run-to-failure maintenance strategy. The need for repairs is determined by operating personnel as part of their normal watch routine. Repairs are normally performed by ship's force personnel, assisted as necessary by an IMA or outside contractor.

•• It has been determined that five years is a "safe" interval between overhauls of the boiler main and auxiliary steam stops and the guarding valves, because ships have operated for nearly five years without a discernible increase in the failure rates of these valves. *However, five years should not be construed to be the maximum repair interval.* It is anticipated that the overhaul interval could be extended beyond five years but that the element of risk involved could not be assessed, since no ships have operated for longer than five years between ship overhauls.

• Recommendations

•• 600 psi boilers installed in AFS-1, AOE-1, AOR-1, and AO-177 Class ships should be scheduled for industrial-level overhaul at intervals of 10 years.

•• During the operating cycle (between boiler overhauls), boilers and boiler accessory equipments should be maintained according to the following maintenance strategies:

-- Boiler-related piping systems (bottom blow, surface blow, soot blower, and high-pressure and low-pressure drain), soot blower heads (wall thickness only), and boiler tubes should be maintained under an on-condition maintenance strategy. Necessary repairs or renewals should be projected on the basis of the trends in periodic ultrasonic test results and boiler tube sampling techniques.

-- Castable refractory and burner tile should be replaced at approximately five-year intervals during a selected restricted availability (SRA). Renewal of castable refractory and burner tile should be accomplished in conjunction with the five-year boiler strength and integrity inspection. The original version of this report suggested the possibility of extending the time between boiler strength and integrity inspections to 10 years and recommended that NAVSEA and NAVSSES review past data pertinent to the inspection. In the time since the issuance of the original report, NAVSSES provided comments on the original version indicating that they had reviewed that possibility. They determined that extending the interval between boiler strength and integrity inspections from 5 to 10 years was not warranted.

- •• Main and auxiliary steam stops and associated guarding valves should receive class B overhauls at five-year intervals. To minimize the likelihood of cumulative failures during the operating cycle, it is recommended that a staggered overhaul approach be adopted that will provide for the class B overhaul of a portion of the installed valves during each industrial availability. This approach will yield a mix of recently overhauled valves, valves at mid-overhaul cycle, and valves approaching the five-year limit.

The remaining technical and maintenance strategy recommendations resulting from analyses of AFS-1, AOE-1, AOR-1, and AO-177 Class 600 psi boilers, accessory equipments, and boiler-related valves and piping are presented in Chapter Four (Table 4-1).

CONTENTS

CONTENTS (continued)

CHAPTER ONE

INTRODUCTION

1.1 BACKGROUND

System engineering analyses (SEAs) are being conducted on selected systems and subsystems of designated ships of the Mobile Logistic Support Force (MLSF) in support of an engineered operating cycle (EOC) program. The SEA is an analysis of the impact of historical preventive and corrective maintenance requirements that affect the operational performance and maintenance programs of a ship system. It serves as a vehicle for assessing the significance of these maintenance requirements to an EOC Program. The objective of this SEA is to define and document a maintenance program for the 600 psi boilers, boiler blow systems, and boiler steam escape systems installed aboard AFS-1, AOE-1, AOR-1, and AO-177 Class ships that will prevent or minimize the need for unscheduled maintenance, while improving material condition and maintaining or increasing system availability throughout an engineered operating cycle.

This revised report includes the results of a separate analysis of the top-fired boilers on AO-177 Class ships (data were limited to AO-177; data for other ships of the class were not reviewed). Incorporation of these results represents the most significant revision to this report. Other revisions or additions to the report were made as necessary on the basis of comments received from NAVSEA 522 and NAVSSES 022E.

1.2 SCOPE

The analysis documented herein is specifically applicable to the ship's 600 psi propulsion boilers, boiler blow systems, and boiler steam escape systems, ship's work authorization boundaries (SWAB) 221-1, 221-3, and 221-4, respectively, installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships. It considers only the systems and equipments installed and documentation effective as of 30 September 1980 (30 June 1981 for AO-177). These systems were selected for analysis by PERA (CSS) on the basis of their mission criticality and historical maintenance burden.

The analysis used all available documented data sources from which system maintenance requirements could be identified and studied. These included the maintenance data system (MDS), casualty reports (CASREPs),

planned maintenance system (PMS) requirements, past ship alteration and repair packages (SARPs), post-overhaul analysis reports (POARs), system alteration information, system technical manuals, and Destroyer Engineered Operating Cycle (DDEOC) system maintenance analyses (SMAs) previously conducted for functionally similar systems and equipments installed on DDEOC Program ships. Sources of undocumented data used in this analysis included discussions with ships' operating personnel and cognizant Navy technical personnel.

1.3 REPORT FORMAT

The following chapters describe the analysis approach (Chapter Two), present the significant system maintenance experience and essential maintenance requirements (Chapter Three), and summarize the conclusions and recommendations derived from the analysis (Chapter Four). Appendix A defines the system boundaries used in conducting this analysis; Appendix B lists the specific components that constitute the 600 psi boiler systems as installed on individual ships of the ship classes under study; Appendix C presents the CASREP summary; Appendix D provides a summary of boiler-related shipalts applicable to AFS-1, AOE-1, and AOR-1 Class ships; Appendix E reproduces the EDTA boiler waterside cleaning procedures, and Appendix F lists all sources of information used in the analysis.

CHAPTER TWO

APPROACH

2.1 OVERVIEW

This chapter describes the approach followed in performing the SEA for the 600 psi main propulsion boiler, boiler blow systems, and boiler steam escape systems installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships. These systems were selected for analysis by PERA (CSS) on the basis of their mission criticality and historical maintenance burden. Data from sources mentioned in Section 1.2 were used to identify, define, and analyze maintenance requirements that will significantly affect the system's operational availability and material condition. A recommended maintenance strategy and implementation procedures were formulated on the basis of the analysis results. The major steps of the analysis were as follows:

- Task 1: Compile data and prepare maintenance history profile
- Task 2: Analyze problems and causes
- Task 3: Analyze solutions to problems
- Task 4: Document SEA results

The following sections briefly describe these major tasks.

2.2 TASK 1: COMPILE DATA AND PREPARE MAINTENANCE HISTORY PROFILE

During Task 1, the configuration, boundaries, and functions of the system were defined; maintenance, engineering, and operating data were collected; and the maintenance history profile was prepared to describe the corrective maintenance historically performed. These items provided basic reference data for the remaining SEA tasks. A major result of this task was a functional description of the selected system or equipment.

2.2.1 Collect Data

The analysis began with the collection of data on the historical maintenance requirements of each system. The resulting data file consisted of four key elements: an MDS data bank, a CASREP narrative summary, a current equipment configuration summary, and a summary of historical maintenance

requirements. A library was also assembled from appropriate technical manuals, PMS requirements, SARPs, POARs, and copies of previously completed analyses of functionally similar equipments installed on DDEOC Program ships.

The MDS data bank was compiled by examining all MDS data reported for hulls AFS-1, -3, -4, -5, -6, and -7; AOE-1 through -4; and AOR-1 through -7 (17 ships total) from 1 January 1971 through 30 June 1980. Data for AO-177 were reported between 1 January 1981 and 31 July 1981. Data on AFS-2 were not included in the analysis, because they were inadvertently omitted from the data base because of an error in the unit identification code used to request the data initially. However, this omission does not affect the analysis results. No effort was made to reorder the data, because the limited potential for improvement of the MDS data bank did not warrant the expenditure of time and funds necessary to obtain and integrate AFS-2 data.

CASREP information was obtained by reviewing the CASREPs reported on each ship's system during the data period 1 January 1977 through 30 June 1980 (1 January 1981 through 31 July 1981 for the AO-177). CASREPs resulting from parts cannibalization of equipments by other ships were not considered.

2.2.2 Define System Configuration

Configuration information was obtained by reviewing available common configuration class lists (CCCLs), the type commanders' coordinated shipboard allowance lists (COSALs), shipalt records, and MDS data. Telephone calls to specific ships and cognizant technical personnel were made as necessary to confirm system configuration.

2.2.3 Prepare Maintenance History Profile

The maintenance history profile was prepared by analyzing MDS and CASREP data and reviewing applicable PMS documentation, past SARPs, and POARs. The maintenance history profile describes the types of corrective and restorative maintenance historically performed on the system, the level of maintenance typically required to perform the work, an estimate of the man-hours required, and the approximate intervals at which these maintenance actions can be expected to recur if such an interval can be determined.

2.3 TASK 2: ANALYZE PROBLEMS AND CAUSES

In Task 2, the data summarized on the maintenance history profile forms were analyzed, together with the available engineering data, to identify maintenance, support, and design problems and their associated causes. The problems and their causes were confirmed and data concerning additional problems were identified through discussion with ship's force and Navy technical personnel when possible.

2.3.1 Analyze Data to Define Problems

Recurring maintenance requirements affecting the availability and material condition of the equipments constituting the system were identified by screening the maintenance history profiles developed in Task 1. This screening had two major objectives:

- To identify recurring failure modes or problems that require IMA, depot, or other off-ship assistance for correction and are associated with all engineering designs of the functionally similar equipments installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships
- To identify recurring failure modes or problems that are either unique to or primarily associated with a particular equipment engineering design installed on a limited number of hulls

Once the problems were identified, the previously completed DDEOC Program SMAs for functionally similar equipments were reviewed to determine whether the same or similar problems had been previously identified on other ship classes. If such was the case, the need for additional detailed analysis was minimized.

2.3.2 Define Causes

Although it is presented as a separate subtask, the definition of problem causes was a continuing process, concurrent with the definition of the problems. Concurrent effort was required for one or more of the following reasons:

- Problem causes were sometimes stated in the historical maintenance data.
- Causes or possible causes of problems were identified during discussions with Navy technical personnel or ships' forces.
- Problem causes had previously been identified by analysis of identical or functionally similar systems installed on other ship classes.

In general, the causes were grouped into three categories -- maintenance strategy, design, and support.

2.3.3 Summarize Problems and Causes

The problems identified and the causes defined in Task 2 were summarized and carried forward to Task 3 for development of specific solutions. The summary descriptions included the following data:

- A statement of the problem and the most probable cause
- A summary of the pertinent maintenance history and engineering data, including man-hours, number of actions, and level of repair
- Other information affecting the problem, such as redesign work in progress, applicable alterations, or the effects of availabilities

2.4 TASK 3: ANALYZE SOLUTIONS TO PROBLEMS

In Task 3 the problems identified in Task 2 were analyzed so that a recommendation could be made regarding a maintenance strategy, a support strategy, or design changes for the associated equipments, or equipment that should be replaced.

2.4.1 Analyze Existing Solutions

The analysis of existing design solutions that might be applicable to the three ship classes under study had two basic objectives. The first was to determine whether the problem was known to the Navy technical community and whether or not a solution had been proposed or defined. To determine this information, currently authorized shipalts affecting the system or equipment under study were reviewed and, if necessary, interviews were conducted with Navy technical personnel.

The second objective was to determine if the specific problem existed in other ship classes and, if it did, whether a solution had been defined and whether it was applicable to the problem associated with the ship classes under study. To meet this objective, previously completed analyses of functionally similar equipments installed on other ship classes were reviewed, and the various problems found were evaluated for similarity. If the problems were determined to be similar to those identified in this analysis, the previously developed solutions were assessed for applicability to the particular equipments installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships. If found to be applicable, they were adopted and documented as recommendations in this report without further detailed analysis.

2.4.2 Analyze Potential Maintenance Strategies

Previously developed maintenance strategies for functionally similar equipments installed on other ship classes were reviewed for their applicability to equipment installations on AFS-1, AOE-1, AOR-1, and AO-177 Class ships. If shown to be applicable by this analysis, they were adopted and recommended for implementation on these classes of ships.

Where previously identified maintenance strategies did not apply to AFS-1, AOE-1 AOR-1, and AO-177 Class systems or equipments, maintenance strategies that might apply were analyzed by using reliability-centered maintenance (RCM) logic. This approach used the information developed during previous tasks to answer a series of simple yes-no questions, which led to specific decisions concerning the suitability of scheduling maintenance tasks. Three types of maintenance tasks could result from the decision process:

- On-condition task - Inspect equipment operation to detect either experienced or impending failures
- Scheduled rework task - Rework an item before an established maximum age or operating interval is exceeded

- Scheduled discard task - Discard an item before an established maximum age or operating interval is exceeded

The results of this process led to the development of the maintenance strategies recommended for the systems and equipments under study for which previously developed maintenance strategies were inadequate.

2.4.3 Analyze Potential Solutions to Integrated Logistics Support (ILS) Problems

Analysis of possible improvements to the ILS of the systems and equipments under study was limited to only those systems or equipments having maintenance history profiles that indicated the presence of ILS problems. Such problems are typically identified during review of MDS or CASREP data. Excessive downtime awaiting parts and the lack of authorized on-board spares as reported in CASREPs indicated the existence of ILS problems. MDS narratives were also used to identify ILS problems, since the deferral codes frequently indicated that a particular maintenance action was deferred for lack of spare parts, technical documentation, or training or experience on the equipment. Where ILS problems were identified, previously completed analyses of functionally similar systems or equipments were reviewed to determine if similar ILS problems had been identified. If they had, and if satisfactory solutions had been defined and recommended, those solutions were adopted and documented as recommendations in this report without further detailed analysis. If not, further analysis was conducted to define an appropriate solution.

Each ILS problem was assessed in terms of its significance and the feasibility of successfully implementing a cost-effective solution. Only those solutions judged to be essential and cost-effective were recommended.

2.4.4 Select Effective Solutions

An effective solution was selected by the analyst on the basis of its merit or essentiality with respect to its projected cost and risk. All candidate solutions, whether resulting from this analysis or from previously conducted analyses of functionally similar equipments, that were judged to improve personnel safety or primary mission reliability were evaluated, and the best solutions, in terms of value versus cost, were selected and recommended for implementation. Candidate solutions to problems not significantly related to personnel safety or mission reliability were assessed on the basis of projected cost and feasibility. If these candidate solutions were not clearly feasible, or if their value, in terms of reduced maintenance burden or improved equipment reliability, was not significant, they were not recommended for implementation.

2.5 TASK 4: DOCUMENT SEA RESULTS

The Task 4 approach was to present the analysis results in a concise, logical format that included an introduction to the SEA objectives, a summary of the technical approach used, a presentation of the analysis results, and a section listing the specific conclusions and recommendations resulting from the analysis. Appendixes were included as necessary to show pertinent data affecting the system, including a table defining the equipment configurations by allowance parts list (APL) number for each AFS-1, AOE-1, AOR-1, and AO-177 Class ship included in the analysis.

CHAPTER THREE

RESULTS

3.1 SYSTEM BOUNDARIES AND DESCRIPTION

The 600 psi main propulsion boilers, as discussed in this report, are composed of those equipments associated with SWABs 221-1 (propulsion boiler system), 221-3 (boiler blow system), and 221-4 (boiler steam escape piping). All the major equipments described within the boundaries presented in Appendix A were examined to identify maintenance requirements. The major components examined and discussed in this report are listed by APL number in Appendix B. Minor associated equipment such as gages, thermometers, instrumentation, draft indicators, external fittings, furnace lighting tube fittings, inspection hole fittings, air-operated lubricators, and sediment strainers were not examined in detail, because past experience has shown that these components are not maintenance- or mission-critical and are usually repaired or replaced as needed by ship's force personnel. They do not normally require periodically scheduled repairs beyond routine calibration of gages and thermometers.

The 600 psi propulsion boilers installed on AFS-1, AOE-1, AOR-1, AO-177 Class ships are all functionally similar in that they generate the steam used to drive the main propulsion turbines, the ship's service steam turbine generators, the main feedpumps, the forced draft blowers, and all other accessory equipments using steam as a prime mover. Although there are some minor design differences among the various steam generators installed on the first three ship classes, they are all oil-fired, D-type boilers consisting of a steam drum and a water drum connected by banks of inclined generating tubes, water screen tubes, side and rear waterwalls, downcomers, associated headers, refractory, a superheater, a desuperheater, an economizer, a double wall casing, and accessories. The accessories, in general, provide for the safe and efficient operation of the boiler and consist of fuel oil burners, combustion controls, feedwater controls, soot blowers, safety valves, water level indicators, and miscellaneous valves and piping, including the boiler blow system. The principal design differences noted among the various boiler installations are related to the overall steam generation capacity, the number of burners installed whether or not steam air heaters are used, the design of the superheater (vertical or horizontal), and location of the desuperheater (steam drum or water drum). Variations in steam-generating capacity are a function of the number and size of boilers installed. Variations in individual boiler designs are a function of manufacturer preferences. The boilers on AO-177 Class ships have

significant differences in design from the other boilers. These differences and their effect on boiler maintenance are discussed in Section 3.3.

AFS-1, AOE-1, AOR-1, and AO-177 Class ships have different (by APL) propulsion boilers, procured from three different manufacturers. With the exception of AFS-1 Class ships, boiler installations consist of some combination of right- and lef-hand boilers. Except for those on AO-177 Class ships, the boilers are essentially identical and will be discussed together in this report. AFS-1 Class ships use only left-hand boilers. Table 3-1 summarizes the boiler configuration as installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships.

Table 3-1. SUMMARY OF BOILER CONFIGURATIONS

APL Number	Manufacturer	Applicable Hulls	Quantity per Hull
(LH) 021200180	Babcock & Wilcox	AFS-1, -2, and -3	3
(LH) 021200186	Babcock & Wilcox	AFS-4, -5, -6, and -7	3
(LH) 021450056 * (RH) 021450057	Combustion Engineering	AOE-1	4
(RH) 021450061 * (LH) 021450062	Combustion Engineering	AOE-2	4
(LH) 021450068 * (RH) 021450069	Combustion Engineering	AOE-3	4
(RH) 021200187 * (LH) 021200188	Babcock & Wilcox	AOE-4	4
(RH) 021550091 * (LH) 021550092	Foster-Wheeler	AOR-1, -2, -3, -4, -5, -6, and -7	3
(RH) 021450089 * (LH) 021450090	Combustion Engineering	AO-177, -178, -179	2

*Combinations of right- and left-hand boilers that constitute the total ship boiler installation.

Each AFS-1 and AOR-1 Class ship has three propulsion boilers installed, and each AOE-1 Class ship has four. Two boilers will support all normal missions and shipboard evolutions. Consequently, the AOE-1 Class ships can conduct all normal operations with two boilers inoperative. However, on AFS-1 and AOR-1 Class ships one or more primary mission areas will be degraded if more than one boiler is inoperative.

AO-177 has only two boilers. Only one boiler is required for 15-knot cruising, while two boilers are required for all other underway operations. Therefore, loss of one boiler degrades one or more primary mission areas.

These installation design differences were considered during the development of the maintenance concept for the 600 psi boilers installed in AFS-1, AOE-1, AOR-1, and AO-177 Class ships. Specific boiler design differences are not discussed in this report unless they contribute to a significant difference in the maintenance history of a specific boiler.

3.2 MAINTENANCE REQUIREMENT IDENTIFICATION

Maintenance data were initially screened to identify the possible existence of significant maintenance-related problems unique to a particular engineering design, as discussed in Section 2.3. Maintenance burden summaries for the installed 600 psi boilers are presented in Tables 3-2 through 3-5.

Table 3-2 summarizes the historical maintenance burdens of the AFS-1, AOE-1, and AOR-1 600 psi boilers and major accessory equipments as reported through the maintenance data system (MDS). Table 3-3 summarizes the same information for AO-177 boilers. The reported burdens are listed by equipment APL number where that number is known. A large quantity of data applicable to such boiler accessories as safety valves, soot blowers, fuel oil burners, and gage glasses was reported under the boiler APL, and although they were deleted from the boiler burden, they could not always be associated with a specific APL. In these cases, "unknown" is entered in the APL column. The reported burden for these unknown APLs was taken into consideration in calculating the average man-hours expended per ship operating year for generic equipment types (e.g., soot blowers, safety valves, gage glasses, and fuel oil burners).

Table 3-4 presents a comparison by ship class of the average maintenance man-hours and JCNs reported per ship operating year for the boilers and major accessories. With the exception of gage glasses and soot blowers, Table 3-4 shows a striking similarity in the historical maintenance burdens of functionally similar equipments without regard to ship class, minor differences in equipment designs, or different manufacturers.

Table 3-5 summarizes the significant corrective maintenance data for boilers for the AFS-1, AOE-1, and AOR-1 Class ships by specific maintenance area and the MDS-reported burden associated with preventive maintenance actions. The corrective maintenance area and the preventive maintenance burden are ranked according to the percentage each contributes to the total burden for the class. Again, the data in Table 3-5 indicate that relative maintenance burdens associated with specific boiler maintenance areas are very similar without regard to ship class. Clearly, the total reported boiler maintenance burdens are essentially the same across the three ship classes listed. The distribution of that burden among the various boiler maintenance areas, including preventive maintenance, is also very similar.

Because the AO-177 is a relatively new ship as compared with the other ships (it was commissioned in January 1981) and has accumulated little operating time, there has been little need for repairs. Consequently, burden data for AO-177 are not included in Tables 3-4 and 3-5.

Table 3-2. SUMMARY OF MDS MAINTENANCE BURDENS FOR 600 PSI BOILERS AND ACCESSORY EQUIPMENTS BY SHIP CLASS AND MANUFACTURER

APL	Nomenclature	Applicable Hulls	Components per Ship	Total Component Population	Total Ship-Operating Time (Ship-Years)	Ships Reported	No. of JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)	Average Man-Hours per Component per Operating Year	Average Man-Hours per Ship per Operating Year by Equipment Type
AFS-1 Class (Babcock and Wilcox)													
021200180	Main Boiler	AFS-1,2*&3	3	6	16.7	2	618	15,972	4,483	20,455	18,299.71	408.3	1,019.4
021200186	Main Boiler	AFS-4,5,6 &7	3	12	34.7	4	875	18,725	13,219	31,944		306.9	
300020114	Fuel Oil Burner	AFS-4,5,6 &7	9	36	34.7	4	43	697	891	1,588	9,392.61	5.1	32.3
300080098	Fuel Oil Burner	AFY-1,2*&3	9	18	16.7	2	13	50	24	74	31.80	0.5	
882170316	Drum Safety Valve	AFS-1-7	6	42	51.4	6	46	699	27	721	6,428.65	2.3	22.1
882170317	S/H Safety Valve	AFS-1-7	3	21	51.4	6	32	322	95	417	2,922.61	2.7	
813020213	Soot Blower Head	AFS-1,2*&3	3	6	16.7	1	4	108	0	108	0	2.1	69.4
813020214	Soot Blower Head	AFS-1,2*&3	18	36	16.7	2	26	78	334	412	8,816.00	1.4	
813020279	Soot Blower Head	AFS-7	21	21	9.1	1	10	1,296	67	1,363	680.98	7.1	
813020280	Soot Blower Head	AFS-7	3	3	9.1	0	0	0	0	0	0	0	
813020281	Soot Blower Head	AFS-7	6	6	9.1	1	2	12	0	12	0	0.2	
813020276	Soot Blower Head	AFS-4,5&6	18	54	25.6	3	53	569	476	1,045	[illegible]	2.3	
813020277	Soot Blower Head	AFS-4,5&6	3	9	25.6	2	16	111	25	136	4,928.32	1.8	
813020278	Soot Blower Head	AFS-4,5&6	6	18	25.6	1	1	6	0	6	0	0.0	
Unknown*	Data Transferred fm. Boiler Narratives	AFS-1-7					14	267	220	487	-		
450020252	Boiler Gage Glass	AFS 3-7	3	15	43.1	5	52	854	1,060	1,914	6,751.70	14.8	
382030009	Smoke Indicator	AFS-3,4,5,6&7	AFS-3(3);4,5,6,&7(6)	27	43.1	2	2	0	0	0	27.00	0.0	0.0
382010002	Smoke Indicator	AFS-1	3	3	8.3	1	2	0	0	0	40.44	0.0	
AOE-1 Class (Combustion Engineering and Babcock and Wilcox)													
021450056	Main Boiler, C.E. (LH)	AOE-1	2	2	8.1	1	262	2,360	606	2,966	18,500.06	91.5	1,062.0
021450057	Main Boiler, C.E. (RH)	AOE-1	2	2	8.1								
021450061	Main Boiler, C.E. (LH)	AOE-2	2	2	8.1	1	272	6,961	3,925	10,886	8,741.09	335.4	
021450062	Main Boiler, C.E. (RH)	AOE-2	2	2	8.1								
021450068	Main Boiler, C.E. (LH)	AOE-3	2	2	8.1	1	262	6,403	7,287	13,690	57,277.57	422.5	
021450069	Main Boiler, C.E. (RH)	AOE-3	2	2	8.1								
021200187	Main Boiler, B&W (LH)	AOE-4	2	2	8.2	1	263	5,391	1,582	6,973	29,085.78	212.6	
021200188	Main Boiler, B&W (RH)	AOE-4	2	2	8.2								

(continued)

Table 3-2. (continued)

APL	Nomenclature	Applicable Hulls	Components per Ship	Total Component Population	Total Ship-Operating Time (Ship-Years)	Ships Reported	No. of JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)	Average Man-Hours per Component per Operating Year	Average Man-Hours per Ship per Operating Year by Equipment Type
AOE-1 Class (Combustion Engineering and Babcock and Wilcox) (continued)													
300080091	Fuel Oil Burner	AOE-1	2	2	8.1	1	4	0	0	0	6,166.40	0.0	
300080092	Fuel Oil Burner	AOE-1	2	2	8.1	1	1	0	0	0	0	0.0	
300080086	Fuel Oil Burner	AOE-1	16	16	8.1	1	18	33	0	33	11,362.39	0.3	
300080110	Fuel Oil Burner	AOE-2	16	16	8.1	1	24	62	70	132	3,524.80	1.0	
300080111	Fuel Oil Burner	AOE-2	2	2	8.1	1	4	37	0	37	88.48	1.1	25.0
300080112	Fuel Oil Burner	AOE-2	2	2	8.1	1	1	0	0	0	2.49	0.0	
300080107	Fuel Oil Burner	AOE-3	16	16	8.1	1	28	83	144	227	11,648.00	1.8	
300020115	Fuel Oil Burner	AOE-4	20	20	8.2	1	12	44	0	44	8,251.62	0.3	
Unknown	Data trnsfrd. fm. Boiler Narratvs.						12	340	0	340	-		
882170280	Drum Safety Valve	AOE-1,2&3	12	36	24.3	3	16	172	2	174	5,350.82	0.6	
882170281	Pilot Safety Valve	AOE-1,2&3	4	12	24.3	3	15	142	106	248	4,370.77	2.6	
882170282	Super Heater Safety Valve	AOE-1,2&3	4	12	24.3	3	8	43	1	44	11,967.00	0.5	
882170367	Drum Safety Valve	AOE-4	4	4	8.2	1	5	17	2	19	531.62	0.6	19.2
882170368	Superheater Safety Valve	AOE-4	4	4	8.2	1	1	0	0	0	187.40	0.0	
882170369	Pilot Safety Valve	AOE-4	2	2	8.2	1	1	2	0	2	0	0.1	
882170370	Pilot Safety Valve	AOE-4	2	2	8.2	1	1	0	0	0	36.30	0.0	
Unknown**	Data Transferred fm. Boiler Narratives						8	78	60	138	-		
813030039	Soot Blower Head	AOE-1,2&3	AOE-1:8, AOE-2&3:4	16	24.3	3	18	41	24	65	267.92	0.5	
813030040	Soot Blower Head	AOE-1&2	20	40	16.2	1	1	8	0	8	0	0.02	
813030051	Soot Blower Head	AOE-2&3	4	8	16.2	2	15	43	185	228	464.68	3.5	
813030058	Soot Blower Head	AOE-3	20	20	8.1	1	12	160	181	341	766.28	2.1	
813020264	Soot Blower Head	AOE-4	4	4	8.2	1	2	8	24	32	0	1.0	
813020265	Soot Blower Head	AOE-4	12	12	8.2	1	5	158	56	214	247.48	2.2	
813020266	Soot Blower Head	AOE-4	4	4	8.2	1	6	2	1	3	425.55	0.1	55.4
813020267	Soot Blower Head	AOE-4	8	8	8.2	0	0	0	0	0	0.0		
813020268	Soot Blower Head	AOE-4	8	8	8.2	1	5	151	1	152	1,698.60	2.3	
Unknown**	Data Transferred fm. Boiler Narratives	-	-	-	-	-	9	577	181	758	-	-	
450010047	Boiler Gage Glass	AOE-2	2	2	8.1	1	8	6	0	6	887.32	0.4	
450010048	Boiler Gage Glass	AOE-2	2	2	8.1	1	5	44	0	44	23.24	2.7	
450020180	Boiler Gage Glass	AOE-1	2	2	8.1	1	11	33	0	33	1,759.73	2.0	23.0
450020181	Boiler Gage Glass	AOE-1	2	2	8.1	1	2	1	0	1	1,606.80	0.1	

(continued)

Table 3-2. (continued)

APL	Nomenclature	Applicable Hulls	Components per Ship	Total Component Population	Total Ship-Operating Time (Ship-Years)	Ships Reported	No. of JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)	Average Man-Hours per Component per Operating Year	Average Man-Hours per Ship per Operating Year by Equipment Type
AOE-1 Class (Combustion Engineering and Babcock and Wilcox) (continued)													
450030025	Boiler Gage Glass	AOE-3&4	2	4	16.3	2	1.	27	0	27	8,767.48	0.8	
450030026	Boiler Gage Glass	AOE-3&4	2	4	16.3	2	17	48	179	227	1,756.28	7.0	
Unknown**	Data Transferred fm. Boiler Narratives	-	-	-	-	-	19	243	165	408	-	-	
382030010	Smoke Indicator	AOE-1,2,3&4	4	16	32.5	2	12	62	0	62	256.86	0.5	1.9
AOR-1 Class (Foster-Wheeler)													
021550091 021550092	Main Boiler Main Boiler	AOR 1-7 AOR 1-7	3	21	50.7	7	1,549	33,456	18,576	52,032	125,494.15	342.1	1,026.3
300080120	Fuel Oil Burner	AOR 1-6	6	36	50.7	6	80	61	334	395	14,505.53	1.3	
300080121	Fuel Oil Burner	AOR 1-6	3	18	50.7	6	26	174	42	216	8,006.95	1.4	24.1
300080137	Fuel Oil Burner	AOR-7	3	3	50.7	1	0	0	0	0	8.17	0.0	
300080138	Fuel Oil Burner	AOR-7	6	6	50.7	1	7	26	0	26	2,417.01	0.1	
Unknown**	Data Transferred fm. Boiler Narratives					-	14	444	139	583	-		
882170340 882170342	Drum Safety Valve Superheater Safety Valve	AOR 1-7 AOR 1-7	6 3	42 21	50.7 50.7	6 6	13 12	39 125	0 0	39 125	5,769.86 11,996.95	0.1 0.8	18.4
882170344	Pilot Sfty. Vlve.	AOR 1-7	3	21	50.7	4	22	127	285	412	4,854.90	2.7	
Unknown**	Data Transferred fm. Boiler Narratives					-	9	273	82	355	-		
813030065	Soot Blower Head	AOR 1-7	3	21	50.7	6	26	261	717	978	642.55	6.4	45.3
813030066	Soot Blower Head	AOR 1-7	18	126	50.7	5	28	601	171	772	275.54	0.8	
Unknown**	Data Transferred fm. Boiler Narratives					-	8	332	215	547	-		
450030025	Boiler Gage Glass (RH)	AOR 1-7	1 or 2	21	50.7	7	36	309	130	439	8,154.68	19.9	70.3
450030026	Boiler Gage Glass (LH)	AOR 1-7	1 or 2			7	130	1,408	1,187	2,595	28,615.53		
Unknown**	Data Transferred fm. Boiler Narratives					-	17	299	230	529	-		
384030054	Remote Water Level Ind.	AOR 1-7	6	42	50.7	6	33	475	374	849	7,144.46	2.8	16.7
382030009	Smoke Indicator	AOR 1-7	3	21	50.7	4	7	2	0	2	82.40	0.0	0.0

*AFS-2 data not included in this report.
**Indicates data erroneously reported under the boiler APLs and transferred to the appropriate component. Exact APLs unknown.
[1]Data reported on APL 300080107 only - TYCOM COSAL does not show other APL as applicable.

Table 3-3. SUMMARY OF MDS MAINTENANCE BURDENS FOR TOP-FIRED BOILERS ON AO-177

APL	Nomenclature	Total Component Population	Ship Operating Time (Years)	Number of JCNs	Man-Hours			Parts Cost (Dollars)	Average Man-Hours per Component per Operating Year	Average Man-Hours per Ship per Operating Year by Equipment Type
					Ship's Force	IMA	Total			
021450089	Main boilers	1	0.55	3	0	0	0	487.23	0.0	0.0
021450090	Main boilers	1	0.55							
300080146	Fuel Oil burner	4	0.55	2	0	0	0	36.67	0.0	0.0
450030032	Boiler gage glasses	1	0.55	1	0	0	0	1,847.27	0.0	0.0
450030033	Boiler gage glasses	1	0.55							
882170340	Boiler safety									
882170347 882170356 882170404	Boiler safety valves	6	0.55	1	0	0	0	293.50	0.0	0.0
882010603	Boiler blow valve	12	0.55	1	2	0	2	101.78	0.3	3.6
Totals				8	2	0	2	2,766.45	0.0	0.0

Table 3-4. COMPARISON BY SHIP CLASS OF AVERAGE MAINTENANCE MAN-HOURS AND JCNs FOR 600 PSI BOILERS AND BOILER ACCESSORIES AND EQUIPMENTS

Equipment Type	AFS-1 Class		AOE-1 Class		AOR-1 Class	
	Man-Hours*	JCNs*	Man-Hours*	JCNs*	Man-Hours*	JCNs*
600 PSI Boilers	1,019.4	29.1	1,062.0	32.6	1,026.3	30.5
Fuel Oil Burners	32.3	1.1	25.0	3.2	24.1	2.5
Safety Valves	22.1	1.5	19.2	1.7	18.4	1.1
Soot Blowers	69.4	2.5	55.4	2.2	45.3	1.2
Boiler Gage Glasses	37.2	1.0	23.0	2.4	70.3	3.6
Smoke Indicators (Periscopes)	0.0	--	1.9	0.4	0.0	--

*Average maintenance man-hours or JCNs reported per ship operating year by equipment type = Total man-hours or JCNs reported for each equipment type (from Table 3-2) / Total ship operating years included in the data period for each ship class

Note: Total ship operating years = AFS-1 Class, 51.4; AOE-1 Class, 32.5; and AOR-1 Class, 50.7.

On the basis of the data presented in Tables 3-4 and 3-5, it was concluded that the historical maintenance requirements associated with boilers and boiler accessories are essentially the same for this basic design of 600 psi boilers, regardless of ship class or boiler manufacturer. Therefore, the specific boiler maintenance requirements and overall maintenance strategies identified as a result of this analysis should be applicable to all AFS-1, AOE-1, and AOR-1 boiler installations. Where the design of the AO-177 Class ships is similar to that of the other classes, recommendations are applicable to all four classes. Specific recommendations for AO-177 Class ships that are design-dependent are listed separately.

It should be noted that the total burdens presented in Table 3-5 are somewhat smaller than the totals shown for the various boilers in Table 3-2. Table 3-2 reflects all man-hours reported against the various boiler APLs. Table 3-5 shows only those maintenance actions directly applicable to the boiler APLs under analysis (Appendix B). It does not include parts-only actions, which do not report associated man-hours; deferred actions that were not closed out; and actions that were judged to be routine or insignificant (e.g., routine valve packing, replacement of "flexitallic" gaskets, "O" rings, and fasteners). Because of the limited quantity of data available, AO-177 is not included in the table.

Maintenance Area	Number of Actions	Percentage of Total Actions	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Average Man-Hours per Ship per Operating Year*	Percentage of Total Burden	Relative Ranking By Percentage of Total Burden
AFS-1 Class (51.4 Ship-Operating Years)								
PMS	112	40.4	13,462	5,849	19,311	375.7	55.0	1
Refractory	41	14.8	2,246	4,950	7,196	140.0	20.5	2
Drums and Headers	41	14.8	2,062	239	2,301	44.8	6.6	5
Air Casing	45	16.3	2,631	326	2,957	57.5	8.4	3
Boiler Tubes	31	11.2	2,116	766	2,882	56.1	8.2	4
Sliding Feet	5	1.8	228	157	385	7.5	1.1	6
Economizers	2	0.7	56	0	56	1.1	0.2	7
Totals	277	[illegible]	[illegible]	12,287	35,088	682.6	100.0	
AOE-1 Class ([illegible] Ship-Operating Years)								
PMS	110	[illegible]	[illegible]	3,947	15,125	465.4	52.8	1
Refractory	43	[illegible]	[illegible]	4,815	6,405	197.1	22.4	2
Drums and Headers	[illegible]	19.3	[illegible]	[illegible]	2,423	74.6	8.4	3
Air Casing	38	12.8	[illegible]	[illegible]	1,679	51.7	5.8	5
Boiler Tubes	30	[illegible]	[illegible]	[illegible]	2,273	69.9	7.9	4
Sliding Feet	8	[illegible]	[illegible]	324	419	12.9	1.5	6
Economizers	10	3.4	[illegible]	[illegible]	336	10.3	1.2	7
Totals	296	[illegible]	[illegible]	11,197	28,660	881.8	100.0	
A[illegible]-1 Class ([illegible] Ship-Operating Years)								
PMS	147	[illegible]	[illegible]	7,246	25,813	509.1	[illegible]	1
Refractory	88	[illegible]	[illegible]	5,293	12,601	248.5	27.5	2
Drums and Headers	45	[illegible]	[illegible]	914	3,266	64.4	7.1	3
Air Casing	47	13.3	[illegible]	243	2,022	[illegible]	4.4	4
Boiler Tubes	12	3.4	[illegible]	[illegible]	1,203	[illegible]	2.6	5
Sliding Feet	5	1.4	[illegible]	113	[illegible]	2.6	0.3	7
Economizers	9	[illegible]	[illegible]	572	[illegible]	14.9	1.7	6
Totals	353	100.0	[illegible]	14,615	45,791	903.2	100.0	

Table 3-5. SUMMARY AND RELATIVE RANKING BY SHIP CLASS OF MDS MAINTENANCE BURDENS FOR 600 PSI BOILERS

*Average man-hours devoted to maintenance area per ship-operating year = $\frac{\text{Total man-hours reported for each maintenance area}}{\text{Total ship-operating years included in the data period for each ship class}}$

CASREP analyses supported MDS data in identifying repetitive or significant maintenance actions. Appendix C summarizes the CASREPs reported against the main propulsion boilers and accessory equipments and indicates the percentage of total system CASREPs attributed to each equipment and, where possible, the type of failure mode experienced.

Results obtained from MDS and CASREP data were corroborated by ship visits and discussions with boiler inspectors of the Readiness Support Group (RSG), Norfolk; personnel at the Naval Sea Center, Atlantic (NAVSEACENLANT) (Code 710); NAVSSES, Philadelphia (Code 022E); and NAVSEA (PMS-301). The objectives were to determine maintenance requirements and to develop appropriate maintenance strategies.

The available MDS and CASREP data for the 600 psi boilers and accessory equipments, shown in Table 3-3 and 3-4, were examined to identify any maintenance tasks that would periodically require the assistance of an IMA, depot, or maintenance activity other than ship's force. The following sections present the significant failure modes identified, with the associated corrective maintenance, as well as the maintenance recommendations. The data are discussed by functional component for clarity and ease of presentation. The order of component discussion is as follows:

Component	Section
600 PSI Boilers	3.2.1
Boiler Accessory Equipments	3.2.2
Boiler-Related Valves and Piping	3.2.3
PMS-Related Maintenance	3.2.4
Boiler-Related Tests and Inspections	3.2.5

Because of similarities in boiler construction and materials, AO-177 boilers are expected to have a maintenance experience similar to other 600 psi ships. However, the newness of AO-177 has precluded any significant maintenance reporting, preventing confirmation of this similarity. We expect that AO-177 (and sister ships) will experience repairs and problems similar to those of other ships and thus will require similar repairs and inspections throughout their useful lives. As a consequence, the following discussion applies to boilers installed on the three classes -- AFS-1, AOE-1, and AOR-1 -- analyzed in the original report on this SEA (ARINC Research Publication 2614-11-3-2485, June 1981) and the AO-177 Class boilers. The general solutions to identified problems apply equally to all four ship classes, as does the recommended maintenance strategy. Recommendations made for one ship class are applicable only to that class unless otherwise stated. AO-177 Class top-fired boilers are described separately (when different from the AFS-1, AOE-1, and AOR-1 Class boilers) in Section 3.3 An overall maintenance strategy for all 600 psi boilers is presented in Section 3.4. All recommendations are summarized by type and equipment in Chapter Four.

3.2.1 600 PSI Boilers

Table 3-5 summarized significant corrective maintenance data for boilers of the AFS-1, AOE-1, and AOR-1 Class ships by specific maintenance area and the MDS-reported burden associated with PMS actions. Although the total reported man-hour burdens for each maintenance area vary somewhat among the three ship classes, the distribution of the total burden among the various maintenance areas is remarkably similar. For those three ship classes, the PMS-related maintenance burden exceeds 50 percent of the total reported boiler maintenance burden and is composed almost exclusively of man-hours reported for waterside and fireside cleaning. In terms of corrective maintenance, only the areas of refractory, drums and headers, air casings, and boiler tubes have sufficient reported burdens to be considered significant. Repairs to sliding feet and economizers have been minimal. The types of maintenance activities that have been responsible for the reported man-hour burdens within each of the corrective maintenance areas are discussed in the following subsections.

3.2.1.1 Boiler Refractory

Although the average man-hours devoted to refractory repairs per ship per operating year varies for each of the three ship classes, the percentage of total boiler maintenance burden attributed to refractory repairs is quite consistent from class to class (20 to 27 percent). A review of CASREP data (see Appendix C) failed to identify any CASREPs that were directly related to refractory failures.

The MDS narratives indicated that most of the refractory maintenance was routine and was normally accomplished by ship's force personnel. Routine refractory repairs consist primarily of the following:

- Patching areas of castable refractory
- Replacing cracked burner tile segments
- Repairing various furnace access door refractory

There were a few instances in which more significant repairs were required and reported in MDS during the operating cycle. Although relatively infrequent, these repairs have included the replacement of furnace front walls and decks and complete replacement of burner tiles, all of which usually require IMA assistance.

Recent discussions with boiler inspectors of RSG, Norfolk, and the Naval Sea Center, Atlantic Detachment (NAVSEACENLANTDET) indicated that refractory deficiencies commonly encountered during boiler inspections tend to be of the same general nature regardless of boiler design or manufacturer. Those deficiencies most commonly noted are as follows:

- Cracked burner tile
- Cracked or crumbling castable refractory

- Dirt and debris in expansion joints
- Eroded furnace decks
- Deteriorated castable refractory or fibrefrax in the superheater cavity
- Deteriorated refractory in various access doors

Most of these deficiencies are not severe enough to require major refractory repairs by an industrial activity. They can be repaired by ship's force personnel with occasional IMA assistance. This information supports the conclusions reached as a result of the review of MDS narratives and CASREPs.

Ship's force personnel concur that there are no significant problems relative to refractory maintenance. The firesides are routinely opened and inspected at each opportunity, and minor repairs are accomplished as needed. Major replacement of burner fronts (tile) and castable refractory is considered within ship's force capability; however, IMA assistance was normally requested if available. The ship's visited considered themselves to be essentially self-sufficient, and although they report having typically received only one IMA availability per year and having steamed approximately 60 to 80 percent of the time (AFS-6, 60 percent; AOE-4, 80 percent), they have not experienced any significant refractory-related problems.

Boiler code personnel of the Naval Ships System Engineering Station (NAVSSES), Philadelphia, state that castable refractory and burner tiles will remain in an acceptable condition for up to five years. Brick refractory (including firebrick, insulating brick, insulating block, and mortar) will last for periods of up to 10 years if properly installed. Although these values represent the expected refractory service life, the need to replace refractory is not totally based on the refractory condition. Other conditions such as the need for major tube renewal or major inner casing repairs may dictate removal and renewal of various refractory areas that would otherwise be in an acceptable condition for continued service. RSG and NAVSEACENLANTDET boiler inspectors and NAVSSES boiler code personnel agree that the need for major refractory replacement is best determined by an inspection of the individual boiler, which considers not only the refractory condition but also the overall boiler inspection results, as well as any impact that general boiler repair requirements might have on refractory renewal.

NSTM Chapter 221, Sections 221-2.339 and -2.340, requires the performance of a boiler strength and integrity inspection at five-year intervals and recommends that this inspection be performed in a Naval shipyard if practical. A 150 percent boiler-design-pressure hydrostatic test may be performed if warranted by the inspection results. The hydrostatic test, if performed, will require removal of the castable refractory around all imbedded tubes so that the tube penetrations can be checked for leakage. As a result, much of the castable refractory will be replaced. In view of the five-year estimated service life for burner tiles and castable refractory and the five-year boiler strength and integrity inspection requirement,

complete renewal of all burner tiles and castable refractory should be scheduled at five-year intervals to coincide with the boiler strength and integrity test. All other refractory should remain in an acceptable condition for up to 10 years. Renewal and repair decisions prior to the end of projected service life should be made on the basis of the results of periodic inspections.

3.2.1.2 Drums and Headers

The MDS maintenance burden for drums and headers has ranged from 44.8 man-hours per ship operating year for AFS-1 Class ships to 74.6 man-hours for AOE-1 Class ships. The majority of the reported man-hours were for ship's force work, with limited assistance provided by IMAs. However, numerous MDS narratives indicated that work had been performed by various outside activities (tenders, ship repair facilities [SRFs], and ship repair departments [SRDs]), but that the associated man-hours were not reported. Review of CASREPs reported by the AFS-1, AOE-1, and AOR-1 Class ships during the period 1 January 1977 through 30 June 1980 identified a total of eight CASREPs attributed to problems related to drums and headers (see Appendix C). The following failure modes were identified in the CASREPs:

Failure Mode	CASREP Severity Code	Number of CASREPs	Ships Reporting
Leaking superheater header handhole plates (pitted)	C-3	1	AOR-2
Cracked superheater header (including baffle plate welds)	C-2	5	AFS-7 (2), AOE-2 (2), AOR-3 (1)
Pinhole leak in superheater inlet header	C-3	1	AOE-2
Defect in superheater inlet header opening	C-2	1	AOR-6

Only two of the CASREPs indicated a severity code reflecting significant degradation in readiness (i.e., C-3), and those CASREPs were corrected in 242 hours (AOR-2) and 172 hours (AOE-2), respectively. Typically, repairs to drums and headers are accomplished with the assistance of an outside activity -- either an IMA or an industrial repair facility. The majority of operating cycle maintenance related to drums and headers concerns cleaning and resurfacing leaking handhole plates and seats, replacing various damaged and missing fasteners for steam drum internals, radiusing various nozzles, smoothing rough welds, preservation, lagging repairs, and grinding out minor hairline indications. All of these actions are accomplished on an as-needed basis. The limited IMA involvement during the operating cycle consists primarily of manufacturing various fasteners for steam drum internals, making lagging repairs, and assisting ship's force personnel in radiusing nozzles and grinding out hairline indications that cannot be deferred until overhaul.

Recent discussions with RSG, Norfolk, boiler inspectors revealed that drums and headers are routinely checked during the start-of-overhaul boiler inspection, and repairs are authorized on an as-needed basis. Drum and header defects discovered during the periodic boiler inspections are handled on a case basis by calling in an IMA to perform either a dye-penetrant (DP) test or an ultrasonic test (UT) on the suspected area to determine the extent of the defect. On the basis of the test results, the suspicious area either is declared satisfactory or is lightly ground, or, in the case of deeper cracks, the indication is ground out and rebuilt with weld. Generally, the IMA activity performing the nondestructive test accomplishes all necessary repairs before closing the boiler.

Ship's force personnel concur that there are no significant problems with drums and headers. Those occasional problems which do occur are generally related to leaking handhole plates and can be resolved by cleaning the handhole seats and replacing the gaskets. Pitted or steam-cut plates can be either resurfaced by an IMA or replaced with an on-board spare. Since only one CASREP was reported for pitted handhole seating surfaces, that failure mode does not appear to be significant. Handhole plate and seating surface repairs should be made on an as-needed basis.

Historically, all handhole and manhole plates have been scheduled for inspection during ROH and approximately one-third have been routinely scheduled for resurfacing or replacement as required during the overhaul. This is considered to be a good engineering practice, since all the handhole plates are routinely removed for other boiler work and it is a convenient time to make necessary repairs. Other repairs to drums and headers have been based on the results of the start-of-overhaul inspection and are accomplished on an as-needed basis.

Two shipalts affecting headers are applicable to ships included in the three classes under consideration: Shipalt AOE-1-421D installs floating superheater header division plates in place of the existing fixed-type plates in Combustion Engineering boilers installed on AOE-1, -2, and -3; and shipalt AOR-1-117D replaces the main boiler superheater headers on AOR-1 through -6. The purpose of both alterations is to reduce or eliminate cracks in the superheater headers.

The current shipalt status (see Appendix D) shows that shipalt AOE-1-421D has been completed on AOE-1 and is scheduled for completion on AOE-2 in 1982 and on AOE-3 in 1985. Shipalt AOR-1-117D has been completed on AOR-5 and is scheduled for completion on AOR-1 in 1984. In addition, this shipalt is applicable to AOR-2, -3, -4, and -6, but is not currently scheduled for accomplishment on these hulls.

Written comments from NAVSSES Code 022E indicate that shipalt AOE-421D corrects a problem that has occurred in some ships. NAVSSES recommended that the shipalt be accomplished only on those ships that experience the problem -- cracking of the attachment welds on the fixed-type superheater header division plate and crack propagation into the header base metal. Otherwise, NAVSSES did not recommend replacement. Because this recommendation reflects repairs accomplished on the basis of material condition, it

limits the number of installations. Therefore, on those ships on which the shipalt has not been accomplished, the division plate attachment welds and the headers should be inspected at the pre-overhaul boiler inspection for cracks and crack propagation. If the cracks are extensive, as determined by the inspector, then shipalt AOE-421D should be accomplished. Otherwise, the cracks should only be repaired.

Shipalt AOR-117D was issued to solve a problem with the seal-welded superheater tube-to-header joints; it installs replacement headers that use a rolled joint instead of the welded joint. If the seal-welded joints are not satisfactory, as determined by inspection, then installation of the shipalt is recommended by NAVSSES. Otherwise, the headers should not be replaced, especially, according to NAVSSES, if the superheaters have been replaced within the last 10 years. NAVSSES has also recommended that "a semi-automatic gas tungsten arc welded (GTAW) joint vice a rolled joint should be considered"* because the welded joint is believed to be more reliable. The suitability of the replacement headers for the GTAW joint should also be evaluated. Because GTAW is a new technique for these headers, the evaluation should be made before GTAW joints are used in accomplishing shipalt AOR-117D.

Discussions with personnel on AO-177 and AO-178, in PMS-301, and in PMS-303 indicate that there is a problem with superheater tube leaks at the superheater header. This problem is currently being studied by NAVSEA, and it is expected to be resolved with minimal long-term effects. Consequently, no additional tasks for AO-177 Class boiler superheaters and superheater headers are recommended at this time. If the leakage problem is not resolved and there is noticeable degradation from the leaks, more frequent hydrotests should be considered in conjunction with the periodic inspections.

Specific drum and header repair requirements cannot be predicted. The requirement for repairs must be determined through periodic inspections, and repairs should be made as the need arises and as recommended above. The only tasks related to drum and header maintenance that should be routinely scheduled for regular overhauls are the following:

- Remove, clean, inspect, repair, and reinstall steam drum internals
- Remove, inspect, repair, reinstall, and hydrostatically test desuperheaters
- Remove, inspect, repair or replace, and reinstall all handhole and manhole plates

3.2.1.3 Air Casings

The maintenance burden for air casing repairs has been relatively small, ranging from 39.9 man-hours per ship per operating year for AOR-1 Class

*NAVSSES letter (022E:WL:mca; 9221(OM-0576); Ser 078; 25 February 1982) to PERA (CSS).

ships to 57.5 man-hours for AFS-1 Class ships. Most of the reported maintenance has been performed by ship's force personnel with only limited IMA assistance. Review of MDS narratives revealed that the types of deficiencies most commonly reported were consistent across all three classes and typically included the following:

- Air leaks
- Bent dogs and broken studs on casing panels and access doors
- Cracks in air casings
- Corrosion and deterioration
- Broken and darkened observation parts

Two CASREPs were reported for air casing problems during the data period. Both were reported by AOR-1 Class ships (see Appendix D). One CASREP was for sheared inner- and outer-casing arch bolts and the other for heavy damage to the air casing due to a flareback. The problem with sheared inner- and outer-casing arch bolts could be related to the fabrication of that particular boiler; however, it has not recurred in other boilers within the class and is not considered to be indicative of a class problem. The second CASREP was the result of an operational accident.

Interviews with ship's force personnel and RSG and NAVSEACENLANTDET boiler inspectors confirmed that most air casing deficiencies encountered during the operating cycle can be repaired by ship's force personnel with occasional assistance by IMAs or other outside activities. The absence of recurring CASREPs for air casing problems supports this observation. Air casing repair requirements during the operating cycle generally have been limited to replacement of broken observation ports, and occasionally minor casing cracks have been welded. All these repairs are routinely accomplished on an as-needed basis by ship's force personnel without outside assistance. Both ship's force and cognizant Navy technical personnel expressed the opinion that the air casings of boilers installed on AFS-1, AOE-1, and AOR-1 Class ships can be maintained in a satisfactory material condition for periods of up to 10 years without the need for major industrial-level repairs. This is possible because the major problem of skirt casing corrosion commonly encountered on combatant ships is not a problem on these ship classes since they do not have skirt casings.

ROH repairs routinely authorized for all boiler designs have included the following:

- Repair and regasket all access doors and panels
- Replace all missing or stripped boiler casing studs, bolts, and dogs
- Renew deteriorated sections of air casing
- Conduct air casing tightness test to 15 inches of water

Other repairs, although not routinely authorized, have included the following:

- Renewal of inner casing floor (brick pan)
- Renewal of outer casing panels
- Renewal of complete inner and outer casing (one instance noted)

Since major portions of the outer air casing are normally removed to facilitate the start-of-overhaul inspection and to provide access for other boiler repairs, that inspection represents a convenient occasion for performing the necessary routine repairs. This practice should be continued. However, the need for these routinely authorized repairs should not be considered as a driving factor in the determination of a boiler overhaul interval. Decisions related to major air casing renewals should be made on the basis of the results of the pre-overhaul and start-of-overhaul inspections, without regard to the boiler overhaul interval.

3.2.1.4 Boiler Tubes

The maintenance burden for boiler tubes on the AFS-1 and AOE-1 Class ships has been greater (in terms of percentage of total boiler burden and total man-hours) than the boiler tube maintenance burden for AOR-1 Class ships during the data period. The reason is that the AOR-1 Class ships are relatively new (AOR-5, -6, and -7 having been commissioned in late 1971, mid-1973, and late 1975, respectively) and their average age is much shorter than that of the AFS-1 or AOE-1 Classes (8.77 years for AOR Classes, 12.76 years for AOE Classes, and 12.79 years for AFS Classes). Therefore, it is not likely that age-related problems (e.g., leaking, cracked, and ruptured tubes caused by corrosion, acid attack, scale buildup, and repeated thermal cycling) have had time to develop in this ship class. Since there is no evidence that Foster-Wheeler boilers installed on AOR-1 Class ships have any design differences that would markedly reduce the normally expected tube-related maintenance, it is assumed that the relative AOR Class burden will ultimately approximate that of the AFS and AOE Classes as additional operating time is accumulated.

A review of MDS narratives was conducted to determine the number and types of boiler-tube failure modes reported. These data are summarized in Table 3-6. Table 3-7 summarizes the tube failures reported by CASREP during the period 1 January 1977 through 30 June 1980. Since many of the MDS- and CASREP-reported tube failures did not specify the tube type (e.g., superheater, generating, screen wall), it was not possible to summarize the failure modes by boiler tube type. However, there was sufficient detail in the data to indicate that tube failures were not limited to particular tube types, since some leaks and ruptures could be identified in superheaters, generating banks, and screen wall tubes. The majority of CASREPs reporting boiler tube problems had a severity code of C-2. Six of the 30 CASREPs reported a severity code of C-3, and none reported a severity code of C-4.

Table 3-6. SUMMARY OF BOILER TUBE FAILURES REPORTED BY MDS

Failure Mode	Number of Occurrences by Ship Class and Boiler Manufacturer			
	AFS-1 (Babcock & Wilcox)	AOE-1, -2, and -3 (Combustion Engineering)	AOE-4 (Babcock & Wilcox)	AOR-1 (Foster-Wheeler)
Ruptured	6	7	5	1
Cracked or Blistered	0	4	0	0
Leaking	21	4	1	3
Other	0	3	0	6
Abrasions or Tool Marks	0	0	0	1
Hard Scale	0	1	0	1
Sagging Superheater Tubes	0	0	0	1
Warped Tubes	0	1	0	1
Removal of One Pass of Superheater	0	1	0	0
Leaks at Superheater Tube*	0	0	0	2

*Major repairs to welded superheater tubes in number 2 boiler of AOR-1 and number 3 boilers in AOR-2 entail milling out of old weld and rewelding. Both tasks were completed by IMA. Exact details are unknown.

Table 3-7. SUMMARY OF BOILER TUBE FAILURES REPORTED BY CASREP

Failure Mode	Number of Occurrences by Ship Class and Boiler Manufacturer			
	AFS-1 Through -7 (Babcock & Wilcox)	AOR-1, -2, and -3 (Combustion Engineering)	AOR-4 (Babcock & Wilcox)	AOR-1 Through -7 (Foster-Wheeler)
Ruptured	3	8	1	3
Cracked or Blistered	0	2	0	0
Leaking	3	3	0	5
Warped and Sagging	0	0	0	2

Two of the six CASREPs were reported as C-3 because there was a concurrent CASREP on a second boiler, and two CASREP boilers significantly degrade mission readiness.

Commonly recurring problems related to boiler tubes include leakage at the drum or header penetrations and cracked, blistered, and ruptured tubes. Occasionally there is a requirement to acid-clean a boiler because of hard-scale buildup, but this is not common. Cracked and ruptured boiler tubes are routinely treated the same way; they are either replaced or plugged at the drum and header penetrations and allowed to burn away during operation or are removed at the time of plugging. Ship's force personnel indicate that they are normally capable of performing this task when necessary. Replacement of tubes will probably require assistance from an IMA.

Over long periods of time, general wall thinning due to waterside corrosion and erosion also becomes a factor. General wall thinning can be routinely monitored by using the British Boiler Tube Inspection Unit (BTIU) during pre-overhaul or start-of-overhaul boiler inspections. Use of the BTIU coupled with routinely authorized removal of a tube sample (consisting of two generating tubes and one screen tube taken from two-thirds furnace depth before regular overhaul) should adequately assess the status of general tube thinning and the amount and type of waterside deposits present. With these results, the requirement for acid cleaning and major tube renewals can be projected and planned for in the overhaul.

Written comments on the original version of this report (ARINC Research Publication 2614-11-3-2485, June 1981) were received from NAVSSES Code 022E. NAVSSES agreed with these statements about wall thinning and further recommended that the BTIU inspection "be performed at least 6 months but not more than 18 months prior to the major industrial periods."* This comment amplifies the statements made in this report and more explicitly defines the inspection period(s).

Only one shipalt related to boiler tubes was identified during the analysis. Shipalt AFS-236D provides stiffening devices for the boiler generating tubes to reduce propeller-induced vibration that has historically led to leaks and tube failures. Current shipalt status information indicates that this alteration is applicable to AFS-1, -2, -5, and -7. The alteration is reported complete on AFS-2; however, there is no current scheduling information for the remaining applicable hulls. This alteration should be scheduled for completion on the remaining applicable hulls during the next regular overhaul.

There is no evidence in the MDS and CASREPs to indicate that there are any particular tube-related problems unique to individual boiler designs installed in AFS, AOE, and AOR Class ships. Accepted repair techniques for ruptured and leaking boiler tubes are well documented in the applicable boiler technical manuals and in Chapter 221 of NSTM, and are normally within

*NAVSSES letter (022E:WL:mca; 9221( )M-0576); Ser 078; 25 February 1982) to PERA (CSS).

ship's force capability with occasional IMA assistance. Neither individual tube failures nor major multiple tube failures resulting from general overheating (due to low-water casualties) are predictable. Both must be dealt with as they occur. The presence of randomly failed (plugged) tubes within the various circuits, excluding those tubes which may not be plugged (superheater support tubes, screen wall tubes, and downcomers), does not significantly degrade boiler performance. Therefore, the maintenance strategy of choice for boiler tubes during the operating cycle is run-to-failure. Major tube renewal requirements for overhaul should be based on the results of periodic inspections of tube wall thickness by the BTIU and tube sampling techniques. In consideration of the expected 20-year service life of boiler tubes, as indicated in the general design specifications for high-pressure boilers, the boiler tubes are not a limiting factor in determining boiler overhaul intervals.

3.2.1.5 Sliding Feet

MDS data revealed a total of 18 separate labor actions related to the maintenance of sliding feet across the three ship classes. In several cases, a single labor action report covered maintenance on the sliding feet of more than one boiler. Table 3-8 summarizes the maintenance actions reported over the data period. Those actions reported as "not taking grease" or "flush" were not clarified in the data. As a result, it was not possible to determine whether or not they reflected "frozen" sliding feet. It was noted that the five actions reporting frozen sliding feet on AOE-1 Class ships were all reported by AOE-1 and -2; no sliding-foot actions were reported on AOE-3 or -4. No CASREPs were reported for sliding-foot problems.

In view of the relatively few actions reported over the data period and the fact that no CASREPs were reported for sliding-foot malfunctions, it does not appear that they have been a significant source of maintenance

Table 3-8. SUMMARY OF SLIDING-FOOT MAINTENANCE ACTIONS REPORTED IN MDS

Failure Mode or Problem Reported	AFS-1 Class		AOE-1 Class		AOR-1 Class	
	Number of JCNs	Number of Boilers Affected	Number of JCNs	Number of Boilers Affected	Number of JCNs	Number of Boilers Affected
Frozen	0	0	5	7	2	4
Not Taking Grease	1	1	0	0	1	3
Flush	3	8	1	2	0	0
Inspect	1	0	0	0	0	0
Replace Tubing	0	0	1	1	0	0
Repair	0	0	1	2	1	1
Install Movement Indicator	0	0	0	0	1	3

burden or problems. If a particular sliding foot fails to take grease or becomes frozen, flushing techniques are available to remove the old hardened grease and to permit lubrication. This procedure will normally free a frozen sliding foot. NAVSEA 0951-LP-031-8010 describes the flushing procedure used to clean hardened grease from a sliding foot. In the event that the binding is severe, it may become necessary to jack up the drum or header to free the sliding foot. Procedures to be used in jacking drums and headers are detailed in NSTM Chapter 221, Section 221-2.365. There should be virtually no requirement to jack up a drum or header if routine lubrication is performed and if the sliding feet are flushed at the first indication of clogged grease passages or lack of movement.

Figure 9-2 in NAVSEA 0951-LP-031-8010, *Repair and Overhaul of Main Boilers 1200 PSI Steam Propulsion Plant,* illustrates a simple sliding saddle movement indicator. This device is superior to the methods formerly employed to determine sliding-foot movement, i.e., determining by visual inspection (1) that the fitting will not accept grease or solvent or (2) whether grease or debris had been moved by motion of the sliding foot. The principle of the device is equally applicable to 600 psi boilers. Recent discussions with RSG boiler inspectors indicate that some ships have already installed sliding-foot movement indicators; however, they are not installed on every ship. AO-177 Class ships were built with sliding-foot movement indicators. Boiler inspectors have encouraged installation of this device when its absence has been noted during inspections; however, the extent to which this installation is completed on AFS, AOE, and AOR Class ships is unknown. It is suggested that emphasis be placed on installing sliding-foot movement indicators on all ships with main propulsion boilers, since these devices will eliminate the "guess work" in determining the need for corrective maintenance.

This analysis has determined that problems with sliding feet on boilers have been neither frequent nor severe. Current PMS procedures, if followed diligently, should keep these problems to a minimum. There are no corrective actions that should be routinely scheduled during regular overhauls. Problems should be addressed as they occur and generally should be corrected by ship's force personnel. Occasional assistance by an IMA may be required if a drum or header must be jacked up to free a severely bound sliding foot.

3.2.1.6 Economizers

From the data presented in Table 3-5, it is apparent that economizer problems have been neither frequent nor severe. Of the 21 labor actions reported, 5 were for leaking tubes, 6 for ruptured tubes, 4 for cleaning and preservation, 2 for missing fins, 2 for leaking soot seals, and 1 each for boiling-out contamination, repairing a crack in the tube sheet, and replacing a broken support bracket. Considering the total population (55) of economizers across the three classes and the data period (1 January 1971 through 30 June 1980), economizers have been extremely reliable. Only two CASREPs have been reported during the past 3-1/2 years for economizer problems: one for a leak and one for a tube rupture. Both CASREPs initially reported severity codes of C-2. One was later changed to C-4 when concurrent problems with another boiler were encountered.

In the event of a ruptured or leaking tube in an economizer, the corrective action is essentially the same. The tube must be identified and either plugged or replaced. Ship's force personnel report that they are fully capable of plugging economizer tubes when necessary; however, economizer element replacement will require outside assistance from either an IMA or an industrial activity.

There are virtually no economizer problems; however, when they do occur, the boiler can generally be returned to service in a short time by ship's force action to plug the defective element. Unless multiple ruptures within one economizer are encountered, the effect on boiler operation is minimal and the final corrective action (i.e., element replacement) can be deferred until a scheduled industrial availability. Multiple ruptures have not been a significant problem and individual tube leaks or ruptures cannot be predicted. Ultrasonic testing (UT) of economizer U-bends has been frequently authorized for ROH. It is suggested that the UT of U-bends be scheduled for IMA accomplishment during a pre-overhaul availability so that the requirement for economizer work can be defined before a ship's arrival at the industrial facility. The industrial work package should be defined on the basis of this pre-overhaul inspection and should include replacement of U-bends as determined necessary by the ultrasonic test, replacement of any previously plugged economizer elements, and a post-repair hydrostatic test. The need for economizer repairs is not considered to be a limiting factor in determining the overhaul interval for propulsion boilers.

NAVSSES comments on the original version of this report included a description of an ongoing program to replace cast aluminimum extended-surface economizers in Combustion Engineering boilers. These economizers have experienced shorter-than-expected service lives, and NAVSEA is preparing shipalts to replace them. AOE-1, -2, and -3 have these economizers, which will be replaced via the appropriate shipalts.

3.2.1.7 Recommendations for 600 PSI Boilers

Recommendations for the maintenance of 600 psi boilers installed in AFS-1, AOE-1, AOR-1, and AO-177 Class ships are summarized in this section. For clarity and ease of presentation, individual recommendations are categorized by boiler maintenance areas corresponding to those listed in Table 3-5. The recommendations, by category, are as follows:

- Refractory (Section 3.2.1.1)
  - Ship's force personnel, assisted as necessary by IMAs, should continue to perform routine refractory repairs required during the operating cycle.
  - The replacement of burner cone tile and all castable refractory should be routinely scheduled at five-year intervals to coincide with performance of the five-year boiler strength and integrity inspection.

- - All decisions concerning renewal and repair of brick refractory before the end of projected service life should be made on the basis of the results of boiler inspections.

- Drums and Headers (Section 3.2.1.2)

  - - The removal, cleaning, inspection, and repair of steam drum internals should be routinely scheduled during each regular overhaul.
  - - The removal, inspection, and repair of all handhole and manhole plates and seating surfaces should be routinely scheduled during each regular overhaul. Approximately one-third of the handhole plates should be resurfaced or replaced.
  - - The removal, inspection, repair, reinstallation, and hydrostatic test of desuperheater elements should be routinely scheduled during each regular overhaul.
  - - All other drum and header repair requirements should be based on the combined results of the pre-overhaul and start-of-overhaul boiler inspections.
  - - Shipalt AOE-421D should be installed only on ships on which division plate attachment welds have extensive cracking, as determined by inspection. Otherwise, it is necessary only to repair the cracks.
  - - Shipalt AOR-117D should be installed only on ships on which the seal-welded superheater tube-to-header joints are not satisfactory, as determined by inspection.
  - - Replacement superheater headers (for use in the installations of shipalt AOR-117D) should be evaluated for the suitability of the gas tungsten arc-welded (GTAW) joint instead of the rolled joint before the GTAW process is used.

- Air Casings (Section 3.2.1.3)

  - - The maintenance of boiler air casings at the organizational level should be continued, with occasional IMA assistance during the operating cycle.
  - - The following repairs should be routinely authorized during regularly scheduled overhauls:
    - -- Repair and regasket all access doors and panels
    - -- Replace all missing or stripped boiler casing studs, bolts, and dogs
    - -- Renew deteriorated sections of the air casing
    - -- Conduct post-repair air-casing-tightness test to 15 inches of water
  - - The determination of specific areas of inner and outer air casing to be renewed or repaired and all other air casing repair

requirements should be made on the basis of the results of a pre-overhaul or start-of-overhaul boiler inspection conducted by a certified steam generating plant inspector (SGPI).

- Boiler Tubes (Section 3.2.1.4)

  - Ship's force personnel, assisted as required by an IMA, should perform those repairs resulting from boiler tube failures on an as-needed basis during the operating cycle.

  - A BTIU inspection and the removal of a tube sample should be scheduled for at least six months and not more than 18 months before ROH.

  - The need for major tube renewals should be based on the combined results of periodic BTIU inspections and analysis of periodic tube samples.

  - Shipalt AFS-236D for AFS-1, -5, and -7 should be accomplished during the next scheduled overhaul.

- Sliding Feet (Section 3.2.1.5)

  - Any required corrective maintenance should be performed on an as-needed basis. Sliding-foot repairs should not be routinely scheduled during ROH.

  - Sliding-foot indicators similar to that described in Figure 9-2 of NAVSEA 0951-LP-031-8010 should be installed on all AFS, AOE, and AOR Class ships at the earliest opportunity.

- Economizers (Section 3.2.1.6)

  - Ultrasonic testing of a representative number of economizer U-bends by an IMA should be routinely scheduled during pre-overhaul availabilities, and the results should be incorporated into the ROH SARP.

  - Routine replacement of all plugged economizer elements should be included in the ROH SARP.

  - A post-repair hydrostatic test of the economizer should be routinely performed by the overhauling activity only if work has been accomplished on the economizer.

3.2.2 Boiler Accessory Equipments

Boiler accessory equipments include those equipments which provide for a boiler's safe and efficient operation. Accessory equipments are independent of the boiler in terms of maintenance, because they are separately supported and have their own APLs. The principal accessory equipments considered in this analysis and their associated historical maintenance burdens are presented in Table 3-9. Table 3-10 presents the average maintenance man-hours and JCNs per ship-operating year by equipment type and ship class for boiler accessory equipments. The data presented in Tables 3-9 and 3-10 were extracted from Tables 3-2 and 3-4 and are reproduced in

Table 3-9. SUMMARY OF MDS MAINTENANCE BURDENS FOR BOILER ACCESSORY EQUIPMENTS BY SHIP CLASS AND MANUFACTURER

APL	Nomenclature	Applicable Hulls	Components per Ship	Total Component Population	Total Ship-Operating Time (Ship-Years)	Ships Reported	No. of JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)	Average Man-Hours per Component per Operating Year	Average Man-Hours per Ship per Operating Year by Equipment Type
AFS-1 Class (Babcock and Wilcox)													
300020114	Fuel Oil Burner	AFS-4,5,6 &7	9	36	34.7	4	43	697	891	1,588	9,392.61	5.1	32.3
300080098	Fuel Oil Burner	AFY-1,2*&3	9	18	16.7	2	13	50	24	74	31.80	0.5	
882170316	Drum Safety Valve	AFS-1-7	6	42	51.4	6	46	699	27	721	6,428.65	2.3	22.1
882170317	S/H Safety Valve	AFS-1-7	3	21	51.4	6	32	322	95	417	2,922.61	2.7	
813020213	Soot Blower Head	AFS-1,2*&3	3	6	16.7	1	4	108	0	108	0	2.1	69.4
813020214	Soot Blower Head	AFS-1,2*&3	18	36	16.7	2	26	78	334	412	8,816.00	1.4	
813020279	Soot Blower Head	AFS-7	21	21	9.1	1	10	1,296	67	1,363	680.98	7.1	
813020280	Soot Blower Head	AFS-7	3	3	9.1	0	0	0	0	0	0	0	
813020281	Soot Blower Head	AFS-7	6	6	9.1	1	2	12	0	12	0	0.2	
813020276	Soot Blower Head	AFS-4,5&6	18	54	25.6	3	53	569	476	1,045	1,099.56	2.3	
813020277	Soot Blower Head	AFS-4,5&6	3	9	25.6	2	16	111	25	136	4,928.32	1.8	
813020278	Soot Blower Head	AFS-4,5&6	6	18	25.6	1	1	6	0	6	0	0.0	
Unknown*	Data Transferred fm. Boiler Narratives	AFS-1-7					14	267	220	487	-		
450020252	Boiler Gage Glass	AFS 3-7	3	15	43.1	5	52	854	1,060	1,914	6,751.70	14.8	
382030009	Smoke Indicator	AFS-3,4,5,6&7	AFS-3(3);4,5,6,&7(6)	27	43.1	2	2	0	0	0	27.00	0.0	0.0
382010002	Smoke Indicator	AFS-1	3	3	8.3	1	2	0	0	0	40.44	0.0	
AOE-1 Class (Combustion Engineering and Babcock and Wilcox)													
300080091	Fuel Oil Burner	AOE-1	2	2	8.1	1	4	0	0	0	6,166.40	0.0	25.0
300080092	Fuel Oil Burner	AOE-1	2	2	8.1	1	1	0	0	0	0	0.0	
300080086	Fuel Oil Burner	AOE-1	16	16	8.1	1	18	33	0	33	11,362.39	0.3	
300080110	Fuel Oil Burner	AOE-2	16	16	8.1	1	24	62	70	132	3,524.80	1.0	
300080111	Fuel Oil Burner	AOE-2	2	2	8.1	1	4	37	0	37	88.48	1.1	
300080112	Fuel Oil Burner	AOE-2	2	2	8.1	1	1	0	0	0	2.49	0.0	
300080107	Fuel Oil Burner	AOE-3	16	16	8.1	1	28	83	144	227	11,648.00	1.8	
300020115	Fuel Oil Burner	AOE-4	20	20	8.2	1	12	44	0	44	8,251.62	0.3	
Unknown	Data trnsfrd.fm. Boiler Narratvs.						12	340	0	340	-		

(continued)

Table 3-9. (continued)

APL	Nomenclature	Applicable Hulls	Components per Ship	Total Component Population	Total Ship-Operating Time (Ship-Years)	Ships Reported	No. of JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)	Average Man-Hours per Component per Operating Year	Average Man-Hours per Ship per Operating Year by Equipment Type
AOE-1 Class (Combustion Engineering and Babcock and Wilcox) (continued)													
882170280	Drum Safety Valve	AOE-1,2&3	12	36	24.3	3	16	172	2	174	5,350.82	0.6	
882170281	Pilot Safety Valve	AOE-1,2&3	4	12	24.3	3	15	142	106	248	4,370.77	2.6	
882170282	Super Heater Safety Valve	AOE-1,2&3	4	12	24.3	3	8	43	1	44	11,967.00	0.5	
882170367	Drum Safety Valve	AOE-4	4	4	8.2	1	5	17	2	19	531.62	0.6	19.2
882170368	Superheater Safety Valve	AOE-4	4	4	8.2	1	1	0	0	0	187.40	0.0	
882170369	Pilot Safety Valve	AOE-4	2	2	8.2	1	1	2	0	2	0	0.1	
882170370	Pilot Safety Valve	AOE-4	2	2	8.2	1	1	0	0	0	36.30	0.0	
Unknown**	Data Transferred fm. Boiler Narratives						8	78	60	138	-		
813030039	Soot Blower Head	AOE-1,2&3	AOE-1:8, AOE-2&3:4	16	24.3	3	18	41	24	65	267.92	0.5	
813030040	Soot Blower Head	AOE-1&2	20	40	16.2	1	1	8	0	8	0	0.02	
813030051	Soot Blower Head	AOE-2&3	4	8	16.2	2	15	43	185	228	464.68	3.5	
813030058	Soot Blower Head	AOE-3	20	20	8.1	1	12	160	181	341	766.28	2.1	
813020264	Soot Blower Head	AOE-4	4	4	8.2	1	2	8	24	32	0	1.0	
813020265	Soot Blower Head	AOE-4	12	12	8.2	1	5	158	56	214	247.48	2.2	
813020266	Soot Blower Head	AOE-4	4	4	8.2	1	6	2	1	3	425.55	0.1	55.4
813020267	Soot Blower Head	AOE-4	8	8	8.2	0	0	0	0	0	0.0		
813020268	Soot Blower Head	AOE-4	8	8	8.2	1	5	151	1	152	1,698.60	2.3	
Unknown**	Data Transferred fm. Boiler Narratives	-	-	-	-	-	9	577	181	758	-	-	
450010047	Boiler Gage Glass	AOE-2	2	2	8.1	1	8	6	0	6	887.32	0.4	
450010048	Boiler Gage Glass	AOE-2	2	2	8.1	1	5	44	0	44	23.24	2.7	
450020180	Boiler Gage Glass	AOE-1	2	2	8.1	1	11	33	0	33	1,759.73	2.0	23.0
450020181	Boiler Gage Glass	AOE-1	2	2	8.1	1	2	1	0	1	1,606.80	0.1	
450030025	Boiler Gage Glass	AOE-3&4	2	4	16.3	2	17	27	0	27	8,767.48	0.8	

(continued)

Table 3-9. (continued)

APL	Nomenclature	Applicable Hulls	Components per Ship	Total Component Population	Total Ship-Operating Time (Ship-Years)	Ships Reported	No. of JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Man-Hours	Parts Cost (Dollars)	Average Man-Hours per Component per Operating Year	Average Man-Hours per Ship per Operating Year by Equipment Type
AOE-1 Class (Combustion Engineering and Babcock and Wilcox) (continued)													
450030026	Boiler Gage Glass	AOE-3&4	2	4	16.3	2	17	48	179	227	1,756.28	7.0	
Unknown**	Data Transferred fm. Boiler Narratives	-	-	-	-	-	19	243	165	408	-	-	
382030010	Smoke Indicator	AOE-1,2,3&4	4	16	32.5	2	12	62	0	62	256.86	0.5	1.9
AOR-1 Class (Foster-Wheeler)													
300080120	Fuel Oil Burner	AOR 1-6	6	36	50.7	6	80	61	334	395	14,505.53	1.3	
300080121	Fuel Oil Burner	AOR 1-6	3	18	50.7	6	26	174	42	216	8,006.95	1.4	24.1
300080137	Fuel Oil Burner	AOR-7	3	3	50.7	1	0	0	0	0	8.17	0.0	
300080138	Fuel Oil Burner	AOR-7	6	6	50.7	1	7	26	0	26	2,417.01	0.1	
Unknown**	Data Transferred fm. Boiler Narratives					-	14	444	139	583	-		
882170340	Drum Safety Valve	AOR 1-7	6	42	50.7	6	13	39	0	39	5,769.86	0.1	
882170342	Superheater Safety Valve	AOR 1-7	3	21	50.7	6	12	125	0	125	11,996.95	0.8	18.4
882170344	Pilot Sfty. Vlve.	AOR 1-7	3	21	50.7	4	22	127	285	412	4,854.90	2.7	
Unknown**	Data Transferred fm. Boiler Narratives					-	9	273	82	355	-		
813030065	Soot Blower Head	AOR 1-7	3	21	50.7	6	26	261	717	978	642.55	6.4	45.3
813030066	Soot Blower Head	AOR 1-7	18	126	50.7	5	28	601	171	772	275.54	0.8	
Unknown**	Data Transferred fm. Boiler Narratives					-	8	332	215	547	-		
450030025	Boiler Gage Glass (RH)	AOR 1-7	1 or 2	21	50.7	7	36	309	130	439	8,154.68	19.9	70.3
450030026	Boiler Gage Glass (LH)	AOR 1-7	1 or 2			7	130	1,408	1,187	2,595	28,615.53		
Unknown**	Data Transferred fm. Boiler Narratives					-	17	299	230	529	-		
384030054	Remote Water Level Ind.	AOR 1-7	6	42	50.7	6	33	475	374	849	7,144.46	2.8	16.7
382030009	Smoke Indicator	AOR 1-7	3	21	50.7	4	7	2	0	2	82.40	0.0	0.0

*AFS-2 data not included in this report.
**Indicates data erroneously reported under the boiler APLs and transferred to the appropriate component. Exact APLs unknown.
†Data reported on APL 300080107 only - TYCOM COSAL does not show other APL as applicable.

Table 3-10. COMPARISON BY SHIP CLASS OF AVERAGE MAINTENANCE MAN-HOURS AND JCNs FOR BOILER ACCESSORIES AND EQUIPMENTS						
Equipment Type	AFS-1 Class		AOE-1 Class		AOR-1 Class	
	Man-Hours*	JCNs	Man-Hours*	JCNs	Man-Hours*	JCNs
Fuel Oil Burners	32.3	1.1	25.0	3.2	24.1	2.5
Safety Valves	22.1	1.5	19.2	1.7	18.4	1.1
Soot Blowers	69.4	2.5	55.4	2.2	45.3	1.2
Boiler Gage Glasses	37.2	1.0	23.0	2.4	70.3	3.6
Smoke Indicators (Periscopes)	0.0	--	1.9	0.4	0.0	--

$$\text{*Average maintenance man-hours or JCNs reported per ship per operating year by equipment type} = \frac{\text{Total man-hours or JCNs reported for each equipment type (from Table 3-2)}}{\text{Total ship operating years included in the data period for each ship class}}$$

Note: Total ship operating years = AFS-1 Class, 51.4 years; AOE-1 Class, 32.5 years; and AOR-1 Class, 50.7 years.

this section for ease and clarity of presentation. The configuration details for each of these equipments as installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships are presented in Table 3-9 or Appendix B. The following subsections address the historical maintenance burdens experienced by each of the identified accessory equipments. Recommendations related to the maintenance of boiler accessory equipments are also presented.

3.2.2.1 Fuel Oil Burners

The data presented in Table 3-10 clearly show that the average maintenance man-hours per ship operating year historically reported for fuel oil burners across the three ship classes have been relatively low. The specific configurations reported as installed are shown in Table 3-11. A review of the MDS narratives revealed that the principal ship's force maintenance actions have consisted of the following:

- Replacement of "O" rings, seals, packing, and gaskets
- Freeing up of sticking air registers
- Replacement of diffusers
- Adjustment of burners
- Removal of carbon deposits

Those actions most frequently deferred for depot-level assistance included the following:

- Overhaul of burners and air registers

Table 3-11. FUEL OIL BURNER CONFIGURATIONS FOR AFS-1, AOE-1, AOR-1, AND AO-177 CLASS SHIPS

APL Number	Manufacturer and Model Identification	Total Installed per Ship	Applicable Hull
300080097	Todd-CEA Model D-20	9	AFS-1,2&3
300020114	B&W - Modified Iowa	9	AFS-4,5,6&7
300080091	Todd-CEA Model LVC4M(RH)	2	AOE-1
300080092	Todd-CEA Model LVC4M(LH)	2	AOE-1
300080086	Todd-CEA Model LVC4M	16	AOE-1
300080110	Todd-CEA Model LVS4M(RH)	16	AOE-2
300080111	Todd-CEA Model LVS4M(RH)	2	AOE-2
300080112	Todd-CEA Model LVS4M(LH)	2	AOE-2
300080107*	Todd-CEA Model LVS4M	16	AOE-3
300020115	B&W - Modified 3M	20	AOE-4
300080120 (LH)	Todd-CEA Model D-20(LH)	6 3	AOR-3,4,5&6 AOR-1&2
300080121 (RH)	Todd-CEA Model D-20(RH)	6 3	AOR-1&2 AOR-3,4,5&6
300080137 (RH)	Todd-CEA Model D-20(RH)	3	AOR-7
300080138 (LH)	Todd-CEA Model D-20(LH)	6	AOR-7
300080146	Todd-CEA Model D-21(LH and RH)	4	AO-177,-178, -179

*Data reported only for APL 300080107. No other applicable APL listed in TYCOM COSAL. Since each boiler has 5 burners installed, either other identifiable APLs are applicable or the total installed per ship is 20.

- Overhaul of burner safety shut-off assemblies
- replacement of burner leads

Although these actions were normally deferred for depot assistance, there were cases in which IMAs also reported overhaul of burner safety shut-off and barrel assemblies and fabrication of new burner leads for ship's force installation. These cases were infrequent, but their existence indicates that IMAs do have a burner overhaul capability if it is required.

Review of the CASREP data reported since 1 January 1977 revealed that no CASREPs were submitted for fuel oil burner failures during that period.

Therefore, it is concluded that those burner-related maintenance actions which have been experienced have not been significant in terms of decreased mission readiness.

During ship visits, operating personnel indicated that the main problem with fuel oil burners was in controlling fuel oil leaks around burner barrel and safety shut-off device packings. There was no evidence of problems with leaking burners on AO-177 Class ships. Leaks can generally be repaired by ship's force personnel by replacing the various packings from shipboard spares. However, the frequency of replacement and number of burners and safety shut-off devices installed increases appreciably the ship's force maintenance burden. With the exception of the leakage problem, fuel oil burners were considered to be very reliable, with little major maintenance required. Ship's force personnel further expressed the opinion that fuel oil burners and air registers could be maintained for periods of up to 10 years, with only occasional IMA assistance. Industrial-level overhauls or repairs are generally not required during this interval.

Eighteen shipalts have been identified as being applicable to the fuel oil burner installations on AFS-1, AOE-1, and AOR-1 Class ships. Table 3-12 summarizes these alterations by number, title, purpose, applicable hulls, and current status. The only alterations that have an effect on the maintenance of currently installed fuel oil burners are the installation of VITON "O" ring packing glands on the safety shut-off valve spools of Todd atomizers (AFS-154F, AOE-187F, and AOR-132F) and replacement of burner seals (AFS-428D and AOE-484D). Since these alterations may alleviate some of the leakage problems, it is recommended that they be installed on all outstanding hulls at the earliest opportunity. The remaining alterations provide improved operating capability and should be scheduled for accomplishment as ship availability and funding permit.

The results of the analysis show that corrective and restorative maintenance of fuel oil burners has not been a major problem. Ship's force personnel can perform most of the maintenance with occasional assistance from an IMA. Major overhauls of burners and air registers are normally deferred until regular overhaul, where they are routinely authorized for accomplishment. However, there is no evidence to indicate that they could not be operated reliably for up to 10 years without industrial-level overhaul.

3.2.2.2 Safety Valves

The information provided in Table 3-9 indicates that the maintenance of safety valves is carried out predominantly by ship's force personnel with relatively little support from IMAs. The average maintenance man-hours and number of JCNs consumed per ship-operating year for safety valves (as shown in Table 3-10) are relatively low, and the average maintenance burden is approximately the same regardless of ship class or safety valve manufacturer. Review of the MDS narratives, however, revealed numerous JCNs alluding to safety valve leakage, bent spindles, eroded and cut disks, and requirements for safety valve overhauls and repairs. The man-hours typically reported for these JCNs were insufficient to support the magnitude of work requested. There were 13 cases in which the narrative indicated

Table 3-12. SUMMARY OF SHIPALTS FOR FUEL OIL BURNERS

Shipalt Number	Description	Purpose	Applicable Hulls	Status by Individual Hull						
				1	2	3	4	5	6	7
AFS-154F AOE-187F AOR-132F	Todd atomizing system-"O" ring packing	To replace "U" cup packing glands on TODD atomizer safety shut-off valve spools with Viton "O" ring packing glands.	AFS-1,2&3 AOE-1,2&3 AOR-1,2,3,4,5&6	C A C	C C A	C A C	N N C	N - C	N - A	N - N
AFS-239D AOE-269D AOR-253D	Install "NAV-JET" burner system	To replace variable pressure steam atomizers with constant pressure "NAV-JET"	AFS-1,2,3 AOE-2&3 AOR-1,2,3,4,5&6	C 6/N* C	A C 5	A 9 C	N N C	N - C	N - 3	N - N
AFS-350F	Install L.P. air to #1	To install 150 PSI L.P. air connections on number one burner steam lead on each boiler.	AFS-3,4,5,6&7	N	N	A	5	C	A	O
AOE-250D AOR-225D	Boiler-L.P. air for atomization	To provide L.P. air for fuel oil atomization when ship's steam is not available.	AOE-2&3 AOR-1,2,3,4,5&6	N C	C A	A C	N C	- C	- C	- N
AFS-336F AOE-396F	Double handle safety shut-off	To simplify boiler operation during maneuvering conditions.	AFS-1&2 AOE-1,2&3	C 1	A 2	N 5	N N	N -	N -	N -
AFS-428D AOE-484D	Boiler burner seals replacement	To reduce fuel oil and steam leakage.	AFS-1,2,3,4,5,6&7 AOE-1,2,3&4	A/N** 6	A/N 7	A/N A	C/A A	A/5 -	C/5 -	C/A -
AFS-220D AOE-239D	Modify steam atomizing control system. Note: These ALTS are modified by installation of Shipalts AFS-1-239D and AOE-1-269D	To improve performance of steam atomizing control system by preventing loss of fires in main boilers when undergoing a rapid decrease in steam demand.	AFS-1,2&3 AOE-2&3	A N	A C	A 5	N N	N -	N -	N -
AOR-408D	Install thermometers in steam atomization line	To provide an atomizing steam temperature indicator at the ACC gage board.	AOR-1,2,3,4,5,6&7	4	5	5	6	2	3	A
AOR-471D	Fuel oil atomizer steam separators.	No information available.	Not available.							
AOR-491D	Moisture free steam system	To remove excessive moisture and eliminate poor quality wet steam.	AOR-1,2,3,4,5,6&7	A	A	A	A	A	A	A

Legend:

C = Complete N = Not applicable
A = Applicable

Numbers represent year programmed; 1 through 9 represent last digit of years 1981 to 1989.

*Current status shows this alteration as scheduled for accomplishment in FY 1986; however, the shipalt brief indicates that this alteration is not applicable to AOE-1. On the basis of MDS data, it appears that the NAV-JET burners have already been installed on AOE-1. This inconsistency should be resolved.

**The shipalt brief indicates that this alteration is already complete on AFS-4, -6, and -7 and is applicable to hulls 1, 2, 3, and 5 as well. SAMIS status indicated nonapplicability for hulls, 1, 2, and 3 and shows accomplishment scheduled or applicable for hulls 4, 5, 6, and 7. Resolution unknown.

that work had been performed by an industrial activity (i.e., shipyards, ship repair facilities [SRFs], and ship repair departments [SRDs]); however, the associated man-hours were not reported.

Eight safety valve CASREPs were reported over the data period considered, as follows:

Failure Mode	Number Reported	Severity Code
Worn	4	C-2
Bent spindle	1	C-2
Nozzle ring	1	C-2
Broken flange	1	C-2
Ruptured expansion bellows	1	C-3

With the exception of the ruptured expansion bellows, none of the CASREPs indicated a significant degradation in mission readiness.

Recent discussions with personnel of Readiness Support Group, Norfolk, revealed that boiler safety valves were commonly being repaired and overhauled by industrial facilities under commercial industrial service contracts (CISCs). The criterion for using a CISC is an IMA job rejection due to facility overloading. Although IMAs are fully capable of performing safety valve overhauls, the valve shops are routinely backlogged with other work, and since the locally available industrial contractor has the added capability of testing the valve with steam after the repairs or overhaul, the jobs are almost routinely performed under the CISC. This approach to safety valve maintenance accounts for the apparent data anomaly of many JCNs and relatively few man-hours, because the industrial man-hours expended are not reported in the MDS.

Ship's force personnel have performed some safety valve maintenance when necessary. On occasion, they have replaced valve seats and disks, spindle assemblies, springs and washers, and complete valve assemblies. IMAs have also reported some overhauls, but not nearly the number that have been requested. The majority of safety valve overhauls performed by IMAs were probably performed by deployed tenders supporting deployed ships.

During ship visits, ship's force personnel confirmed that safety valves were routinely repaired and overhauled by outside industrial activities. One ship further indicated that it had obtained a spare drum safety valve and that it was currently being tested and set by an industrial activity under a CISC. There is no indication in the appropriate safety valve APLs that complete spare safety valves are authorized as on-board spares; however, MDS narratives indicate several cases in which ships have requested an outside activity to test and set spare safety valves. Therefore, it appears that some ships have obtained one or more spares. These spares can be used to replace defective valves as the need arises. The failed safety valve can then be sent to a tender or industrial activity for repair or overhaul. While this practice is both effective and convenient, it is

also expensive. Considering the low incidence of safety-valve CASREPs and the minimal mission degradation associated with those CASREPs which were reported, it is questionable whether the benefits of authorizing on-board spare safety valves warrant the cost of providing them. However, those ships which have managed to secure on-board spares will find them a convenient means of correcting safety valve problems when they do occur.

Three shipalts affecting the existing safety valve installations on AFS-1, AOE-1, and AOR-1 Class ships were identified during the analysis. These alterations affect the replacement of existing spring-loaded superheater safety valves on all three ship classes with a new design-pressure-seated-type superheater unloader valve. The purpose of these alterations is to improve the reliability of superheater safety valves through the use of improved technology. These shipalts are identified as follows:

- AFS-395K
- AOE-448K
- AOR-423K

The current status indicates that these alterations are applicable to all AFS-1, AOE-1, and AOR-1 Class ships; however, none have yet been installed and none are currently programmed for accomplishment. Although the data analyzed do not indicate that safety valves are a major maintenance problem, much of the reported maintenance is for the repair and overhaul of superheater unloading valves. Installation of the proposed shipalts will improve overall safety valve reliability, because the alterations remove the drum pilot valves completely and replace the spring-loaded superheater unloading valve with a pressure-seated-type valve. Because of their design, these new valves can be set cold and merely tested with steam. All testing and setting of these valves are accomplished at a remotely located control unit and do not require personnel to make "trial and error" adjustments on the valve itself. Not only will the reliability of the superheater unloading valve be improved, but the time and effort required to test and set these valves will be minimized. These alterations should be programmed for completion on all applicable hulls at the earliest opportunity.

With the establishment of CISCs, which provide for the industrial repair and overhaul of boiler safety valves when IMA facilities are overloaded, the maintenance philosophy for boiler safety valves becomes one of run-to-failure throughout the service life of the safety valve. According to personnel of RSG, Norfolk, this maintenance strategy is currently being followed by NAVSURFLANT. Necessary repairs required during deployments can normally be accomplished by ship's force personnel, by using on-board spare parts or by replacing the entire valve assembly if a spare is available. Deployed IMAs are fully capable of overhauling safety valves if it becomes necessary. The combination of IMAs and industrial facilities tasked under CISCs can accomplish all the required safety valve repairs and overhauls that can be deferred until an in-port period. As a result, there is no reason to routinely schedule safety valve overhauls.

3.2.2.3 Soot Blowers

Tables 3-9 and 3-10 show that the average man-hours expended on soot blower maintenance per ship operating year have been fairly consistent across the AFS-1, AOE-1, and AOR-1 Classes, ranging from 45.3 man-hours for the AOR-1 Class to 69.4 man-hours for the AFS-1 Class. These tables further indicate that ship's force personnel have typically performed most of the maintenance with only limited assistance from IMAs.

A review of the CASREPs submitted during the period 1 January 1977 through 30 June 1980 revealed a total of four soot-blower-related failures. Two were for ruptured or leaking soot blower piping and two for inoperative soot blowers. All but one reported severity codes of C-2. The single C-3 CASREP was for a ruptured soot blower line.

A review of the MDS narratives revealed that most of the IMA man-hours were concentrated in relatively few labor actions. For example, 28 IMA actions across the three ship classes accounted for 2,804 IMA man-hours, which are virtually all of the IMA man-hours reported during the data period. A single IMA action for the overhaul of three retractable soot blowers from an AOR-1 Class ship accounted for 644 IMA man-hours. This particular type of maintenance action should not recur, since shipalt AOR-457D authorizes the removal of AOR-1 Class retractable soot blowers (see Appendix D), thus eliminating future maintenance requirements.

The reported ship's force maintenance burden (see Table 3-9) is the result of a variety of tasks, including:

- Overhauling soot blower heads
- Overhauling or replacing air drive motors
- Freeing frozen elements that will not rotate easily
- Replacing bent or warped elements
- Correcting valve leaks
- Replacing gaskets and packing

Recurring maintenance actions that involve IMA support of ship's force personnel and account for the majority of the IMA man-hour burden have historically included the following:

- Overhaul or repair of soot blower heads
- Replacement of deteriorated soot blower piping
- Installation of new soot blower drain valves
- Straightening of bent or warped soot blower elements
- Ultrasonic testing of soot blower heads and piping

Ship's force personnel indicate that soot blowers are not a major maintenance problem and that they are normally capable of performing all required

corrective and preventive maintenance, except for the PMS-required ultrasonic test of soot blower heads and piping, the replacement of deteriorated sections of soot blower piping, and straightening of bent or warped elements. Overhaul of soot blower heads and air motors is normally accomplished by ship's force personnel by using on-board repair parts. IMA assistance is not routinely required.

With the use of diesel fuel, marine (DFM), the requirement to operate soot blowers has been reduced from once each watch on each steaming boiler to once each day. This corresponds to a reduction in soot blower operating time of 83.3 percent. As a result, the rate of wear on moving parts of the soot blower heads has been correspondingly reduced. However, stress on the elements has not been reduced, since they are located in the path of combustion gases whenever the boiler is being fired. Thus the potential for warping remains. Further, the effects of corrosion have not been significantly diminished by the reduction in soot blower operation. As a result, it is expected that ultrasonic testing of soot blower heads and piping will occasionally indicate the need for some replacements.

Recent discussions with RSG, Norfolk, boiler inspectors disclosed that some soot blower elements are difficult to remove from the boiler because of interference and that the only convenient time to inspect and preserve these elements is during an ROH. In this case, the emphasis is on convenience, since there is no evidence that this task must be performed at any particular interval. This task should not be considered a limiting factor in determining boiler overhaul cycles. Likewise, the ultrasonic testing of soot blower heads and piping and any necessary replacements resulting from this test are well within the capability of IMAs and do not necessarily have to be accomplished during an industrial availability.

On the basis of this analysis and discussions with cognizant technical and operating personnel, it does not appear that there is any aspect of soot blower maintenance that would dictate a particular boiler overhaul interval. Given that the existing PMS requirements and periodic ultrasonic testing of soot blower heads and piping could be accomplished, this system could be adequately maintained by ship's force with occasional IMA assistance on a fix-when-fail basis over an extended period of time. When industrial-level boiler overhauls are scheduled, the removal, inspection, and preservation or replacement of soot blower elements should be concurrently scheduled, as well as the replacement of any soot blower heads or piping not meeting the appropriate wall thickness criterion. Because of the greatly reduced usage rate for soot blowers, it does not appear that the routine authorization for overhaul of all soot blower heads is warranted. Their overhaul should be based on individual need as determined by the pre-overhaul boiler inspection or ship's CSMP. The overhaul of soot blower heads could properly be assigned to ship's force for accomplishment during ROH.

3.2.2.4 Boiler Gage Glasses

Tables 3-9 and 3-10 present the historical maintenance burden associated with the various gage glasses installed in AFS-1, AOE-1, and AOR-1 Class

ships. From Table 3-9, it is apparent that the maintenance burden associated with the gage glasses installed on AOR-1 Class boilers is significantly greater than for either of the other two ship classes. A review of the MDS narratives for all gage glasses revealed that the principal failure modes tended to be the same, regardless of manufacturer. The following were the most commonly reported failure modes:

- Gage glass leaking (e.g., cracked glass, flanges)
- Mechanical mating surfaces warped, steam cut, or pitted
- Gage glass clouded
- Gage cut-out valves leaking through

These problems were reported by all ships regardless of class; however, AOR-4 alone reported 11 actions for machining rough and pitted mating surfaces of gage glasses that accounted for 786 IMA man-hours and 856 ship's force man-hours. If the man-hours associated with these reported actions are removed from the AOR-1 Class gage glass data in Table 3-9, the average man-hours per ship per operating year for gage glass maintenance will be 37.9 man-hours, which brings the AOR-1 Class more nearly into line with the burdens experienced by the other two classes.

Discussions with ship's force personnel and RSG, Norfolk, boiler inspectors indicate that the rebuilding of gage glasses is well within ship's force capability. They routinely replace gaskets; repair cut-out valves; and replace glass, mica, spring cone washers, and various component parts of gage glasses. However, they usually request outside assistance to build up and remachine flanges and machined mating surfaces. Most of the reported IMA activity was in this area.

Three shipalts have been developed to improve overall gage glass reliability. Shipalts AFS-325K, AOE-375K, and AOR-273K remove the existing gage glasses and replace them with Yarway 2,500 psi glasses. Current shipalt status does not indicate that any of these alterations have yet been installed (see Appendix D).

Yarway 2,500 psi gage glasses have previously been installed on some other ship classes. In an earlier analysis* of DDG-37 Class main propulsion boilers, performed as part of the DDEOC Program, some observations were made relative to the Yarway 2,500 psi gage glass maintenance experience. Key points from that discussion are restated here for any benefit that they may provide in implementing the shipalts on AFS-1, AOE-1, and AOR-1 Class ships.

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*ARINC Research Publication 1652-03-15-1752, *System Maintenance Analysis, DDG-37 Class Main Propulsion Boilers (SMA 37-108-221), Review of Experience*, May 1978.

Review of DDG-37 MDS data and interviews with cognizant IMA and ship's force personnel indicated that at that time the major maintenance problems associated with Yarway 2,500 psi gage glasses were as follows:

- Inadequate special repair tools at the ship's force maintenance level
- Problems in reassembly of the gage glass, resulting in leaks and broken glass

As part of the shipalt implementation process on auxiliary ships, boiler technical manuals should be modified to ensure that they have sections detailing proper repair procedures. All necessary special repair tools should be provided to the ship as part of the shipalt installation.

Historically, gage glasses have not been a significant problem in terms of mission readiness. No CASREPs were reported for gage glass failures during the data period reviewed. Gage glasses have traditionally been maintained by ship's force personnel, assisted as necessary by IMAs. Generally, they are repaired on an as-needed basis and are not overhauled on a scheduled basis. There is no evidence from this analysis to indicate that the currently installed gage glasses have any reliability or supply support problems that would prevent boiler overhaul cycles from being extended. As a result of this analysis, it does not appear that accomplishment of shipalts AFS-325K, AOE-375K, and AOR-273K is warranted on the basis of improved reliability. Accordingly, these shipalts should be canceled.

3.2.2.5 Smoke Indicators (Periscopes)

The review of MDS data and discussions with ship's force personnel revealed that smoke indicator maintenance is insignificant. Only 21 maintenance actions were reported across all three ship classes, and the man-hour expenditure was insignificant. Ship's force personnel indicated that the only maintenance required was the replacement of light bulbs and the cleaning and occasional replacement of mirrors. All work has been accomplished by ship's force personnel. Since the smoke indicator is neither critical to boiler operation nor maintenance-significant, no recommendations are made. Those few repairs which were required should continue to be performed on an as-needed basis by ship's force personnel. Maintenance requirements associated with smoke indicators will have no impact on an engineered operating cycle.

3.2.2.6 Recommendations for Boiler Accessory Equipments

Recommendations for the maintenance of boiler accessory equipments installed in AFS-1, AOE-1, AOR-1, and AO-177 Class ships are presented in this section. For clarity and ease of presentation, the following recommendations are categorized by specific equipment:

- Fuel Oil Burners (Section 3.2.2.1)
  - Ship's force personnel should perform routine corrective maintenance on an as-needed basis, assisted as necessary by an IMA.

- - All fuel oil burners and air registers should be routinely scheduled for overhaul during regularly scheduled ship overhauls.
  - Accomplishment of the following maintenance-related shipalts should be scheduled on all outstanding ships at the earliest opportunity:
    - -- AFS-154F
    - -- AFS-428D
    - -- AOE-187F
    - -- AOE-484D
    - -- AOR-132F

- Safety Valves (Section 3.2.2.2)
  - The routine scheduling of boiler safety valve overhauls during ROH is unwarranted and therefore is not recommended.
  - Boiler safety valves should be maintained on a run-to-failure basis.
  - Shipalts AFS-395K, AOE-448K, and AOR-423K should be programmed for accomplishment at the earliest opportunity.

- Soot Blowers (Section 3.2.2.3)
  - The removal, inspection, and preservation or replacement of all *soot blower elements should be routinely scheduled* as required during each ROH.
  - The replacement of deteriorated soot blower piping and heads should be scheduled on the basis of the results of an ultrasonic test performed before entering ROH.
  - The overhaul of all soot blower heads during each ROH should not be routinely authorized. Overhaul decisions should be made on the basis of the results of the pre-overhaul boiler inspection and ship's CSMP.

- Gage Glasses (Section 3.2.2.4)
  - The maintenance of gage glasses should be continued at the ship's force and IMA levels on a repair-as-needed basis. The routine scheduling of gage glass overhauls in conjunction with ship overhaul is not warranted.
  - Shipalts AFS-325K, AOE-375K, and AOR-273K should be canceled. If these shipalts are accomplished, steps should be taken to ensure that the following actions are performed:
    - -- Applicable boiler technical manuals are modified to include sections detailing *proper repair procedures* for the Yarway 2,500 psi gage glasses.
    - -- All necessary *special repair tools* are provided to ship's force as part of the Yarway 2,500 psi shipalt implementation.

- Smoke Indicators (Periscopes)(Section 3.2.2.5). There are no recommendations for the smoke indicators (periscopes).

3.2.3 Maintenance of Boiler-Related Valves and Piping

Past analyses of propulsion boiler systems, review of MDS data, and discussions with ship's force personnel all confirm that valves and piping are two of the major boiler-related maintenance burden areas, mainly because of the quantity of valves and piping installed. The historical burdens are difficult to quantify, because of the wide variety of valve types installed and the variations in configuration from hull to hull and ship class to ship class. Most of the piping maintenance is not reported in the MDS, because there are no APLs associated with piping.

During the review of MDS narratives reported under boiler APLs, 136 valve maintenance actions and 83 piping repairs were noted across the three ship classes. The man-hours totaled 7,008 and 4,759 for significant valve maintenance and piping repairs, respectively. This by no means represents the total burden being experienced by fleet personnel, since hundreds of ship's force and IMA maintenance and repair man-hours are reported under 292 different valve APLs for AFS-1 Class ships -- 364 for AOE-1 Class ships and 315 for AOR-1 Class ships.

Not all of the reported valve maintenance is associated with boiler-related valves. However, valve maintenance in general is a continuing burden and, with the exception of welded-in main steam valves, is not amenable to correction by ship overhaul regardless of the overhaul interval selected. Similarly, piping repairs are basically precipitated by internal and external corrosion over extended periods of time.

Specific failures cannot be predicted in terms of time, because of the varying levels of maintenance and different external factors contributing to piping corrosion encountered in various system applications and individual installations. The following subsections present discussions of the specific valve categories and piping areas having the most significant impact on an engineered operating cycle. Valve categories to be discussed include pressure seal bonnet valves, bottom blow valves, and general purpose steam valves. Piping areas most commonly experiencing problems include bottom blow systems, high-pressure and low-pressure drains, and soot blower piping.

3.2.3.1 Pressure Seal Bonnet Valves

Pressure seal bonnet valves, commonly called seal ring valves, are installed in a variety of applications, including main and auxiliary steam stops and guarding valves and certain other steam and main feed systems. Although the valve sizes and manufacturers vary, they are all similar in design and use a seal ring to provide a seal between the valve body and the valve bonnet. The valves used in the main and auxiliary steam stop capacity are provided with a remote-control feature that uses

an air motor to close the valves. These valves must be opened manually. Because of the large number of seal ring valves installed in the three ship classes and the variety of sizes, applications, and manufacturers involved, it was not practical to provide a detailed configuration listing or burden summary. Review of the MDS narratives and discussions with ship's force personnel revealed that the principal failure modes are as follows:

- Leakage past the seat
- Seal ring leakage

Similarly designed valves are also installed in other ship classes. Previously completed analyses* of main propulsion boilers installed on DDG-37, CG-16, and CG-26 Class ships included discussions of problems related to the maintenance and repair of seal ring-type valves that, on the basis of the review of MDS data and discussions with ship's force personnel, are equally applicable to AFS-1, AOE-1, and AOR-1 Class ships.

The following paragraphs describe the previously identified failure modes, together with valve repair and overhaul guidance.

Leakage Past the Seat

Leakage past the seat in steam applications has sometimes been attributed to hairline cracks in the stellite seats, which leak under hydrostatic pressure but do not leak under steam pressure. This anomaly is probably accounted for by the difference between a hydrostatic test at 70°F and a steaming temperature of approximately 800° to 850°F. The problem is especially troublesome, since some hairline cracks leak while others do not. Those valves which experience steam leakage or excessive hydrostatic leakage past the seat must be repaired. The repairs required are usually limited to either lapping the valve seat to remove the cracks or replacing the complete seat.

More significant seat repairs can, in theory, be accomplished by IMA personnel using a portable valve reseating tool. However, this is often difficult to set up aboard ship (because of physical interference at the valve location), and in-place repairs have decreased in favor of shop repairs. IMAs do not usually consider in-place repair, because of the poor accessibility of some valves. As a result, IMAs tend to automatically remove valves from the piping when significant repairs are required. Since many of these valves are welded into level 1 piping systems, the expense of removal (in time and dollars) is considerable. While it is recognized that many valves are truly inaccessible to the reseating tool, many are open to in-place repairs. Therefore, TYCOMs should emphasize to IMAs and industrial facilities that whenever possible, welded-in valves should be repaired in place rather than cut out and repaired in the shop.

**Ibid.*, and ARINC Research Publication 1671-04-3-2119, *System Maintenance Analysis, CG-16 and CG-26 Class 1200 PSI Propulsion Plant, SWAB Group 200 (SMA 1626-200), Review of Experience*, November 1979.

Seal Ring Leakage

Leakage around the seal ring is a frequently cited failure mode. Routine replacement of a leaking seal ring is within the capability of ship's force personnel; however, prolonged leakage can cause steam cuts in the valve body that require machining of the valve body and installation of oversize seal rings. This is normally accomplished by an IMA- or depot-level facility. NAVSEA Notice 9505, dated 24 June 1977, provides the specifics for two oversize dimensions and directs that when the required machining would exceed the maximum allowable dimension (second oversize), the valve body must be built up and remachined to the original specification.

The requirement to machine these valves and install oversize seal rings causes two problems: (1) stocking required oversize seal rings and (2) identifying those valves on which oversize seal rings are installed. In theory, the appropriate valve APL will list the three possible sizes of seal rings (i.e., original, oversize one, and oversize two); however, this is not always true. As a result, required replacement seal rings are not always available. The second problem is related to the inconsistent documentation of valve modifications made by IMAs and industrial facilities. Typically, repair activities will modify the valve, install an oversize seal ring, and fabricate one or two spares. The valve is then reinstalled in the ship, and the spare oversize seal rings are turned over to ship's force personnel.

The principal problem is that the modified valves are not always tagged to show that an oversize seal ring is installed and to indicate whether it is the first or second oversize. Unless ship's force personnel are aware of and keep track of modified valves themselves, there will eventually be no records on which valves have been modified or the specifications to which they have been modified. Spare seal rings will be in the hands of ship's force personnel; however, they may no longer know which valves they will fit. When pressure seal bonnet valves are modified by an IMA or depot, the repair facility should consistently label the valve with a brass tag giving the dimensions of the new ring. Adequate spare rings should be provided to the ship as operating-space spares, and changes to the applicable valve APL should be initiated to reflect that an oversize seal ring has been installed. The spare seal rings should also be labeled to show their size and the specific valves they will fit.

Valve Repair Guidance

Recent discussions with NAVSEA (PMS-301) personnel indicated that NAVSHIPS Technical Manual (NSTM) Chapter 9480 (to be renumbered as Chapter 505) and the three-volume valve manual, NAVSEA 9253-AD-MMO-010, -020, and -030, are undergoing major revisions. As part of those revisions, more extensive and detailed information on the maintenance and repair of pressure seal bonnet valves is being included. However, these revised documents will probably not be issued until the second or third quarter of FY 1982. Until updated information becomes available to the fleet, NAVSEA Notice 9505, dated 24 June 1977, remains the principal guidance for the

repair of pressure seal bonnet valves. Since Notices are normally canceled automatically after a predetermined period of time, NAVSEA Notice 9505 should be re-promulgaged to ensure that it remains available and in effect until revised NSTM Chapter 505 and NAVSEA 9253-AD-MMO-010, -020, and -030 are issued. NAVSEA (PMS-301) personnel further advised that work is continuing at Ship's Parts Control Center (SPCC), Mechanicsburg, Pennsylvania, to review all APLs covering pressure seal bonnet valves to ensure that they include supply-oriented information on the availability of oversize replacement seal rings.

Valve Overhauls

Historically, the routine Class B overhaul of main and auxiliary steam stops and guarding valves has been authorized during regular overhauls. Typically, the overhaul intervals have varied between three and one-half years and five years. Major combatant ships in the DDEOC Program, including FFs, DDs, DDGs, and CGs, have adopted an overhaul cycle of approximately 60 months, which includes the overhaul of main and auxiliary steam stops and guarding valves as part of the overhaul package. Although some repairs have been required, there is no evidence from the historical maintenance data for AFS-1, AOE-1, AOR-1, and AO-177 Class ships to indicate that these valves have presented a major maintenance problem during the operating cycles currently employed. In addition, there is no firm evidence that the overhaul of these valves could be extended beyond five years without introducing an appreciable risk of failure. Since these particular boiler-associated valves are critical to both ship mission and personnel safety, it is recommended that the main and auxiliary steam stops, with their associated operating mechanisms, and the main and auxiliary steam guarding valves be given a Class B overhaul at intervals of approximately five years.

To improve the overall average material condition of these valves during the operating cycle and to minimize the valve overhaul portion of the ROH, it is suggested that the valve overhauls be staggered over the operating cycle. This can be accomplished by scheduling the overhaul of a portion of the installed main and auxiliary steam stops and guarding valves during each industrial availability, systematically rotating through the valves until all have been accomplished and then starting the cycle again. This approach can and should be extended to include all boiler-related steam system valves. In the case of the AFS-1 Class ships currently on a phased maintenance program, the main and auxiliary steam stops and guarding valves scheduled for overhaul during a particular availability should be those associated with the 600 psi boiler scheduled for maintenance.

3.2.3.2 Bottom Blow Valves

All AFS-1, AOE-1, AOR-1, and AO-177 Class ships are equipped with flanged 1-1/2 or 2 inch carbon steel angle and "Y" bottom blow valves. The valves are supported by a variety of APLs and were supplied by several different manufacturers, including Yarway, Walworth Company, Crane, Dresser Industries, Velan Valve Corporation, Rockwell, and Vogt. Typically, there are

approximately 10 bottom blow valves in each boiler, although this figure can vary depending on the particular installation. Because specific configurations vary from ship to ship within a given class and from ship class to ship class, it was not practical to prepare a detailed configuration list of specific valves installed on each ship. Instead, the historical maintenance burden associated with bottom blow valves as reported in the MDS was summarized by totaling the individual burdens contributed by various bottom blow valves as installed in the AFS-1, AOE-1, and AOR-1 Class ships. There was no reported burden for AO-177. Table 3-13 summarizes the aggregate bottom blow valve burden by ship class. Clearly, AOR-1 Class ships have reported a higher average burden per ship operating year than either the AFS-1 or AOE-1 Class ships. However, review of the MDS narratives identified "leaking through" as the recurring failure mode for all bottom blow valves, regardless of ship class or valve manufacturer. This finding is consistent with that previously established during analyses of boilers installed on other ship classes (FF-1052, DDG-37, CG-16, and CG-26).

Table 3-13. SUMMARY OF MDS MAINTENANCE BURDENS FOR BOTTOM BLOW VALVES

Ship Class	Reported APLs	Number of JCNs	Ship's Force Man-Hours	IMA Man-Hours	Total Reported Man-Hours	Average Man-Hours per Ship per Operating Year*
AFS-1	882002202 882002927 882010330 882010488 882010489 882047176 882051572 882055585	62	726	740	1,466	28.5
AOE-1	882001270 882002120 882003005 882010490 882010491 882034390 882044757 882054087 882054127	107	762	835	1,597	49.1
AOR-1	882010490 882010491 882033762 882045567	126	1,148	2,836	3,984	78.6

*Calculated by dividing the total reported maintenance man-hours for the ship class by the total ship operating years in the data period.

Review of CASREP data identified eight CASREPs for bottom blow valves during the data period. Seven of the eight CASREPs were reported by one AOR-1 Class ship. One report was for a stripped stem on the overboard valve, and seven were for various leaking bottom blow valves. All of these CASREPs reported severity codes of C-2, indicating that they were not considered significant to mission degradation. This observation was confirmed during ship visits, when operating personnel indicated that leak-through of bottom blow valves was not normally considered critical.

Interviews with IMA valve shop personnel conducted during previous analyses revealed that repairs of bottom blow valves required a major portion of their time. The data presented in Table 3-13 tend to substantiate that statement for AFS-1, AOE-1, and AOR-1 Class ships, since the IMA burden is consistently greater than that reported by ship's force. IMAs can make virtually all the normal repairs and tests required on bottom blow valves, since they are equipped with the appropriate tools required to perform the work.

Generally, ship's force repairs are limited to repacking the valves, lapping the seats, and replacing individual valves with on-board spares if available. However, on one ship visited it was reported that a hydropump is permanently installed in the work space used for valve repair. Ship's force personnel indicated that they perform many of their own valve overhauls and check their own work by hydrostatically testing the valves following overhaul and before reinstallation. Personnel on the second ship visited indicated that they did not generally attempt to overhaul their own bottom blow valves. The reason given was that they did not have a valve bench-test facility and since they were unable to check their own work by hydrostatic test, they routinely requested an IMA facility to perform necessary repairs. Both ships indicated that they currently have well qualified machinery repairmen and certified high-pressure welders on board to operate installed lathes and milling machines and to make necessary welding repairs to various high-pressure systems. The extent to which valve repair and test benches are installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships is unknown. On the basis of ship's force comments received during ship visits, a considerable improvement in ship's force valve repair capability could be achieved by ensuring that each AFS-1, AOE-1, AOR-1, and AO-177 Class ship is equipped with an installed valve repair and bench-test facility.

In past analyses performed as part of the DDEOC Program, ship's force personnel have reported that several spare bottom blow valves, carried as operating-space spares, were useful. These spares typically consisted of a minimum of six valves (two rearwall header, two sidewall header, one water drum, and one surface blow) that were installed on a particular boiler while the originally installed valves were being repaired by either ship's force personnel or an IMA. This approach to the maintenance of bottom blow valves has the advantage of permitting a staggered overhaul of bottom blow valves, thus improving the overall average material condition of these valves throughout the operating cycle. Since the work can be done on a ship-to-shop basis, ship's force, IMAs, or other outside activities could perform the maintenance on an as-needed basis during the operating

cycle, without having to take a boiler out of service while the repairs are being made. This would improve the overall reliability and availability of the bottom blow system during the operating cycle and would minimize the need for industrial activities to overhaul bottom blow valves during ROH regardless of the ROH interval ultimately chosen.

3.2.3.3 General-Purpose Steam Valves

General-purpose steam valves are generally small- or medium-size (0.5 IPS to 2.0 IPS) gate and globe valves used in a variety of functions to support safe and efficient boiler operation and maintenance. They are supported by a number of APLs and are supplied by various vendors. Boiler-related functions commonly using these types of valves include:

- Main steam bypass valves
- Root steam to soot blowers
- Root steam to steam smothering system
- Atomizing steam valves
- High-pressure and low-pressure drain valves
- Gage glass cut-out valves
- Steam drum and economizer vents
- Chemical injection system valves

Discussions with ship's force personnel indicate that these valves are not a major problem when considered on an individual basis; however, the aggregate burden is substantial. The principal failure modes are essentially the same for all the included functions, as follows:

- Leaking through
- Packing leaks
- Gasket leaks
- Steam-cut flange faces
- Corroded and deteriorated

Most repairs can be performed by ship's force personnel. However, there are occasional maintenance actions that require IMA assistance. These actions are for building up and remachining flange faces and replacing deteriorated valves in level 1 piping systems. The maintenance of general-purpose steam valves has traditionally been performed on an as-needed basis, and there is no evidence from MDS data or from ship visits to indicate a change from that policy. Maintenance of general-purpose steam valves related to boiler operation should not significantly affect an engineered operating cycle. Any maintenance required during an ROH should normally be performed by ship's force personnel. Industrial activities should be involved in only the replacement of deteriorated valves in level 1 piping

systems, and such involvement should be based on the results of the pre-overhaul inspection and the ship's CSMP. There are no recommendations for changes to the existing maintenance policy of the general-purpose steam valves.

3.2.3.4 Boiler-Related Piping Problems

In the review of MDS narratives reported under the boiler APLs, numerous piping repairs were noted. A total of 83 JCNs, involving 1,833 ship's force man-hours and 2,926 IMA man-hours, were reported during the data period across the AFS-1, AOE-1, and AOR-1 Classes. The commonly reported failure modes were as follows:

- Piping ruptured
- Leaking at weld joints
- Deteriorated piping (reduced wall thickness)

These failures were centered in three areas -- bottom blow piping, soot blower piping, and high-pressure drain piping. Review of CASREP data revealed five reports for bottom blow piping, two for soot blower piping, and two for drain piping. Of the five CASREPs for bottom blow piping, three were for holes in the piping. Two of these reports had a severity code of C-2 and one AOR reported a severity code of C-4, indicating a complete loss of bottom blow capability on all three boilers. The remaining two CASREPs for bottom blow piping were reported by an AOE, which indicated below-minimum acceptable standards of wall thickness for bottom blow piping on two boilers. This report had a severity code of C-3. Of the two CASREPs for soot blower piping, one reported ruptured piping (C-3) and one reported a hole in the piping (C-2). The two CASREPs for drain piping were for deteriorated piping, with a severity code of C-2.

Virtually all the piping problems shared one element in common, regardless of the application -- deterioration over a period of time from corrosion. All applicable boiler MIPs for these ship classes include a scheduling requirement for the ultrasonic testing of soot blower heads and piping, high-pressure drain piping from header to first valve, and surface and bottom blow piping from drum or header to the skin of the ship. These tests are to be accomplished during shipyard overhaul when piping damage is experienced and when piping integrity is suspect. Since IMAs are capable of performing ultrasonic testing and necessary repairs, the repair and monitoring of the various piping systems' material condition is not limited to regular ship overhaul at industrial facilities. As a result, repairs to piping systems are not considered a limiting factor in determining overhaul cycles and should not significantly affect an EOC if these systems are ultrasonically tested at necessary intervals to monitor the progressive degradation and permit scheduling of repairs before failure.

Because these piping systems are of various ages and states of material condition, a baseline ultrasonic test should be performed on the bottom

blow, soot blower, and high-pressure drain piping of all AFS-1, AOE-1, AOR-1, and AO-177 Class ships to determine current conditions. On the basis of these test results, a retest schedule should be developed for individual hulls that would adequately monitor progressive piping degradation and permit the scheduling of specific piping repairs or major replacements before failure. Adoption of this or a similar policy for material-condition monitoring of piping system maintenance will improve the overall material condition and minimize the failures that have resulted in CASREPs. The replacement of large sections of deteriorated piping or entire piping systems should be deferred until ROH, because of the magnitude of work involved. However, the need for such repairs should be based on trends in material condition as determined by the previously described periodic ultrasonic test monitoring. Those piping systems which are at or near minimum wall thickness at the time of a regularly scheduled overhaul should be replaced.

Problems related to corrosive deterioration of bottom blow systems on these classes should be minimized by the installation of monel bottom blow systems (shipalts AFS-391K, AOE-445K, and AOR-420K; a shipalt is being prepared for the AO-177 Class). Current shipalt status information indicates that AFS-391K will be installed on AFS-2, -5, and -6 under the phased maintenance program and on all other AFS-1 Class ships during regular overhauls. Shipalts AOE-445K and AOR-420K are applicable to all hulls, and many are already scheduled for accomplishment (see Appendix D). These alterations should be accomplished (in the case of the AO-177 Class, prepared and accomplished) at the earliest opportunity. Implementation of the previously described material-condition assessment program for bottom blow systems should not be deferred until these shipalts are accomplished, because of the long time it will take to install the shipalts and the age of piping currently installed. The policy of material-condition assessment for bottom blow systems should be continued even after monel piping is installed; however, the ultrasonic testing interval may change.

3.2.3.5 Recommendations for Maintenance of Boiler-Related Valves and Piping

Recommendations for the maintenance of boiler-related valves and piping installed in AFS-1, AOE-1, AOR-1, and AO-177 Class ships are presented in this section. For clarity and ease of presentation, the following recommendations are categorized by specific maintenance areas:

- Pressure Seal Bonnet Valves (Section 3.2.3.1)
  - Type Commanders should emphasize the performance of in-place valve repairs, whenever possible, to reduce cost and system downtime.
  - A procedure should be established to ensure that changes in internal dimensions of pressure seal bonnet valves are documented and that appropriate seal ring allowance changes are made.
  - COMNAVSEASYSCOM should repromulgate NAVSEA Notice 9505 to ensure its continued availability and effectiveness until the

revised NSTM Chapter 505 and the three-volume valve manual, NAVSEA 9253-AD-MMO-010, -020, and -030, are issued.

- •• Main and auxiliary steam stops and operating mechanisms and main and auxiliary steam guarding valves should be routinely class B overhauled at intervals of approximately five years. These overhauls should be distributed over multiple industrial availabilities rather than being performed all at once during ROH.
- •• For ships on a phased maintenance program, a Class B overhaul should be scheduled for main and auxiliary steam stops and guarding valves associated with the particular boiler scheduled for maintenance.

- Bottom Blow Valves (Section 3.2.3.2)
  - •• Repairs and overhauls of bottom blow valves should be performed at the organizational or IMA level on an as-needed basis.
  - •• Industrial-level overhaul of all bottom blow valves should not be routinely authorized during ROH. Only those valves known to require corrective maintenance, as determined by either pre-overhaul inspection or ship's CSMP, should be scheduled for overhaul. The work should be screened for IMA accomplishment if there is a concurrent IMA availability.
  - •• Ship's force should be provided with a minimum of six spare bottom blow valves to be carried as operating-space spares.
  - •• The potential benefits to be derived from staggering overhauls of bottom blow valves during the operating cycle should be investigated, and, if warranted, a staggered overhaul policy for bottom blow valves should be implemented.
  - •• The benefits to be gained by installing valve repair and test facilities on all AFS-1, AOE-1, AOR-1, and AO-177 Class ships should be investigated. Appropriate shipalts should be developed to provide this capability, if warranted, on the basis of the investigation results.
- General-Purpose Steam Valves (Section 3.2.3.3). There are no recommendations for the general-purpose steam valves.
- Boiler-Related Piping Problems (Section 3.2.3.4)
  - •• An on-condition maintenance strategy should be adopted for the maintenance of bottom blow, surface blow, soot blower, and high-pressure drain piping.
  - •• A baseline ultrasonic test of bottom blow, surface blow, soot blower, and high-pressure drain piping should be performed on all AFS-1, AOE-1, and AOR-1 Class ships to establish current material condition. Because AO-177 ships are new, this test is not required.
  - •• Retest schedules for individual hulls should be developed on the basis of baseline test results. Arrangements should be made for trending subsequent test results to establish repair and replacement requirements and intervals.

•• The shipalts related to monel bottom blow systems (shipalts AFS-391K, AOE-445K, and AOR-420K, and the as-yet-undeveloped shipalt for the AO-177 Class) should be accomplished at the earliest opportunity.

3.2.4 PMS-Related Maintenance

This section presents an analysis of that portion of the boiler maintenance burden attributed to preventive maintenance, including formal and informal requirements. It is recognized that not all preventive maintenance is routinely reported in the MDS; however, in the analysis, more than 50 percent of the maintenance man-hours reported are associated with maintenance actions of a preventive nature (see Table 3-3). The types of maintenance actions reported in the MDS that were counted as being preventive-maintenance-related are as follows:

- Waterside cleaning
- Fireside cleaning
- Boiler inspections
- Calibration of gages, thermometers, and remote water-level indicators
- Preservation
- Repacking of soot blower head assemblies and general-purpose steam valves

Although some man-hours were reported for each type of task listed, the largest reported man-hour contributor by far was waterside and fireside cleaning. This finding is consistent with the findings of previous analyses performed for 1,200 psi boilers installed on surface combatants included in the DDEOC Program. There was no evidence from PMS requirements or MDS data or discussions with operating personnel, boiler inspectors, or cognizant Navy technical personnel to indicate that fireside and waterside maintenance for 600 psi boilers is different in any significant way from that of 1,200 psi boilers. The elements of waterside and fireside maintenance are identical, regardless of the boiler manufactuer or operating pressure. The principal elements of waterside and fireside maintenance are as follows:

- Boiler lay-up procedures
- Periodic waterside cleaning
- Periodic fireside cleaning
- Maintenance of feedwater quality

The impact of these preventive-maintenance-related elements on ship's force maintenance burdens and on long-term boiler maintenance are discussed in the following sections.

3.2.4.1 Boiler Lay-Up Procedures

The impact of correct boiler lay-up on long-term boiler maintenance is significant in that it helps to prevent the adverse effects of waterside and fireside corrosion and deterioration of refractory due to condensation.

The specific lay-up procedure to be used at any particular time is selected by the engineer officer and is a function of a ship's circumstances. Several different methods are available; however, no one method is satisfactory for all situations, because of the differing operational status of ships. A discussion of boiler lay-up procedures to be used in relation to ship status was presented in the *System Maintenance Analysis for DDG-37 Class Main Propulsion Boilers (SMA 37-108-221)*, prepared for the DDEOC Program. Since that discussion is equally applicable to AFS, AOE, AOR, and AO-177 Class ships, a portion of it is restated in this report.

There are three situations that must be considered in any discussion of boiler lay-up procedures:

- The ship is operational and on short notice to get under way.
- The ship is in an upkeep status and anticipates an in-port period in excess of one month.
- The ship is undergoing an extended restricted availability (RAV) or overhaul at an industrial facility.

These situations are described in the following paragraphs.

Operational on Short Notice

Operational ships on short notice to get under way normally use a steam blanket lay-up, because it permits the ships to fire and steam the boiler with only four hours' notice. This procedure is satisfactory for limited periods of time, but for periods beyond approximately one month other methods must be used. The steam blanket is unsatisfactory for extended periods, because it becomes ineffective in preventing waterside corrosion and could allow contamination of the boiler with silicates from shore steam.

Tests run on shore steam at several locations on the Atlantic coast have shown that the silicate contained in most shore steam condensate is within the maximum allowed; therefore, Atlantic coast ships can use shore steam for steam blankets. On the Pacific coast, however, the silicate level is in excess of the maximum allowed and a wet or dry lay-up is required.

Upkeep

For ships in an upkeep status or undergoing an extended availability requiring that the boilers be layed up for periods exceeding one month, the forced-hot-air lay-up method is preferred. The method consists of forcing dehumidified hot air through boiler drums, tubes, and headers, as well as through the furnace. This approach is effective in preventing waterside corrosion and refractory moisture damage. Ships currently do not have the required blowers, dehumidifiers, and air duct work on board; thus the forced-hot-air lay-up method can be accomplished only by a shipyard. However, NAVSSES has recently drafted a change to NSTM Chapter 221 which provides information on acceptable portable blowers and heaters that can be used for

forced-hot-air lay-up. NAVSSES personnel indicate that appropriate shipalts will be developed to ensure that all ships are provided with forced-hot-air lay-up capability. Specific centrifugal blowers and electric heaters that have been identified as acceptable by NAVSSES are as follows:

- Centrifugal blowers, 440 volt, 3-phase
  - Aerovent, Inc., PB series blowers
  - Cincinnati Fan and Ventilation Company, PB series blowers
  - Coppus Engineering Corporation
- Electric heaters, 440 volt, 3-phase
  - Balad Electric Heating Corporation
  - True Heat Corporation
  - General Electric Company

Implementation of the force-hot-air lay-up capability on AFS, AOR, AOR, and AO-177 Class ships should minimize waterside and fireside corrosion during upkeep periods.

Extended RAV or Overhaul

A third procedure, developed by NAVSSES, Philadelphia, is in use for extended boiler lay-up periods by both the Norfolk and Long Beach Naval shipyards. This method, termed hydrazine lay-up, consists of filling the boiler, back-filling the superheater with feedwater, and treating the boiler water with hydrazine and morpholine. The hydrazine scavenges oxygen from the boiler, and the morpholine maintains the boiler water at the pH necessary for optimum hydrazine performance. Since the hydrazine is used up as it absorbs oxygen, it must be continuously monitored and additional treatment provided to replace the depleted hydrazine. This procedure is used to lay up the boiler for that period of time between the end of boiler repairs and the end of overhaul. The results obtained from using this procedure have been excellent. The current procedure is to dump and refill the boiler before lighting off. However, hydrazine is toxic, and the problem of its disposal has prevented widespread use of this lay-up procedure. Therefore, it is doubtful that this procedure will ever be used by ship's force.

The hydrazine lay-up procedure is less effective than the forced-hot-air lay-up in one important respect. Although the hydrazine treatment is effective in preventing waterside corrosion, it is a cold-water lay-up procedure. As a result, condensation forms on the fireside of the boiler tubes, causing moisture damage to the castable refractory and promoting external corrosion of the tubes. It appears that a combination of the hydrazine waterside lay-up procedure and the forced-hot-air procedure for the firesides may provide the best solution for short- and medium-term shipyard boiler lay-ups.

For extended boiler lay-up periods (6 to 12 months), the forced-hot-air procedure seems to be the best choice, particularly because extended lay-up periods are usually associated with availabilities or overhauls, during which the boiler must be open for repairs. The forced-hot-air lay-up procedure should be specified in the SARP for that portion of the overhaul during which the boilers are open for maintenance.

3.2.4.2 Waterside Cleaning

PMS and NSTM Chapter 221 require the cleaning and inspection of watersides and firesides at an interval not to exceed 2,000 operating hours. Discussions with ship's force personnel indicate that many engineer officers schedule the cleaning of watersides and firesides at approximately 1,800 operating hours. As indicated earlier, the process of cleaning firesides and watersides is the principal contributor to the PMS-related man-hour burden for boilers installed on AFS, AOE, and AOR Class ships. With the advent of change from Navy special fuel oil (NSFO) to DFM, problems with fireside deposits have been greatly reduced. As a result, the time required to clean firesides has been reduced to a point of relative insignificance, because mechanical cleaning is generally sufficient to remove deposits from the firesides without water washing. The man-hour burden related to cleaning watersides has been and continues to be the single largest contributor to PMS-related maintenance.

Until recently, only two methods of waterside cleaning were available. The preferred method was to use a high-pressure water jet, which requires IMA assistance and the use of a portable, diesel-engine-driven high pressure water pump. Normally, three men are required to operate the water-jet equipment after the boiler has been disassembled for waterside maintenance. The second method for waterside maintenance is the use of mechanical, air-driven tube-cleaning equipment. This method must be used when IMA assistance is not available. It is not as effective as water-jetting and typically requires about 30 to 50 ship's force man-hours over a period of about two working days.

With the advent of high-pressure water-jetting, ship surveys confirm that most engineer officers try to schedule waterside cleaning during an intermediate maintenance availability (IMAV) to take advantage of the improved water-jet method offered by most IMAs. Approximately 550 ship's force man-hours per boiler are required to accomplish waterside and fireside cleaning. These man-hours include time spent disassembling and reassembling the boiler, obtaining a satisfactory hydrostatic test, and setting the safety valves. It does not include approximately 50 man-hours required by IMA maintenance personnel to operate the water-jet equipment. The total elapsed calendar time has usually been about 15 working days.

In February 1981, a new method of waterside cleaning was authorized by COMNAVSEASYSCOM message 122140Z, February 1981. This message authorizes the use of ethyldiaminetetraacetate (EDTA) for fleet units. COMNAVSEASYSCOM message 07228Z, March 1981, provides additional information on the use of EDTA. (Copies of both messages are included as Appendix E to this report.) The EDTA method of waterside cleaning was developed by NAVSSES, Philadelphia,

over the past few years as a less labor-intensive method of cleaning watersides. Basically, the procedure consists of a fleet capability to clean a boiler chemically during an under-way or in-port period. Tests have shown that the EDTA procedure will remove approximately 80 percent of waterside soft deposits and some hard scale, although the precise amount has not been determined. The EDTA cleaning procedure is not effective in removing oxygen scabs from watersides; therefore, it cannot totally replace water-jetting and mechanical wire brushes as waterside cleaning methods in cases where hard scale or active oxygen pitting are present. It remains essential for ship's force personnel to maintain their capability to clean boiler watersides mechanically. Accordingly, ship's force personnel should inventory their boiler-cleaning equipment at each SRA to ensure that a complete complement is maintained.

The use of EDTA has one distinct advantage over mechanical and water-jet cleaning methods in that EDTA cleaning can be accomplished without major disassembly of the boiler. This results in significant man-hour savings. The drums and headers must be opened to remove sludge and loose scale; however, the steam drum internals do not require removal, thus saving man-hours and minimizing the commonly recurring problems related to the removal of steam drum internals (e.g., broken studs, J bolts, I bolts; damaged threads). Discussions with NAVSSES, Philadelphia, personnel revealed that recent experience on the USS RANGER (CV-61) and the USS SAIPAN (LHA-2) has been excellent, with the USS RANGER reporting 84 total elapsed hours from the time the boiler went off line to the time it went back on line and the USS SAIPAN reporting a total elapsed time of 72 hours. The USS RANGER estimated a saving of 250 man-hours per waterside cleaning with the use of EDTA. Both the RANGER and the SAIPAN reported that actions took place while they were under way. As yet, no results have been evaluated for in-port use of EDTA; however, the only significant difference expected is that a barge will be required to accept and dispose of the EDTA solutions and the flushing water following the treatment.

Fleet-wide implementation of the EDTA waterside cleaning process will significantly improve overall waterside conditions and greatly reduce the ship's force and IMA man-hours usually required to clean boiler watersides. This will free numerous ship's force and IMA personnel for the performance of other high-priority maintenance-related work.

3.2.4.3 Feedwater Quality Improvement

The quality of feedwater entering a boiler has a profound effect on the condition of the boiler's watersides. In this regard, two shipalts previously developed by PMS-301 for 1,200 psi boilers have been authorized for AFS, AOE, and AOR Class ships. These shipalts provide for the installation of a demineralizer in the feedwater system and for the installation of a morpholine injection system. The applicable shipalts to the AFS-1, AOE-1, and AOR-1 Classes are listed below. Shipalts have not yet been

prepared for the AO-177 Class, although the improvements are expected to be made.

- Demineralizer system
  - •• AFS-276K
  - •• AOE-312K
  - •• AOR-275K
- Morpholine injection system
  - •• AFS-283K
  - •• AOE-319K
  - •• AOR-282K

The purpose of the demineralizer system is to improve boiler reliability by removing dissolved sea salts and metallic ions from make-up boiler feedwater. Installation of the demineralizer system consists of connecting cylinders of activated resin in the make-up feed line and arranging them so that make-up feedwater will be purified before entering the condensate system.

The purpose of the morpholine injection system is to minimize the deposit of corrosion products on boiler heat-transfer surfaces. Installation of this alteration consists of installing a tank and the necessary piping to provide a gravity-fed morpholine injection system to the freshwater-drain-collecting tank. The morpholine injection system will maintain a feedwater pH in the range of 8.6 to 9.0. This will reduce the corrosion normally experienced in the condensate and feedwater piping, because the alkaline condensate will not dissolve the copper and ferric oxides from the piping. The combined action of these shipalts should appreciably improve the quality of feedwater supplied to the boilers. It is recommended that these alterations be accomplished during the next availability of sufficient duration to permit completion of the tasks. The current status of these alterations is presented in Appendix D.

3.2.4.4 Extending the Waterside Cleaning Interval

Completion of the previously described shipalts for installation of demineralizer and morpholine injection systems on all AFS, AOE, AOR, and AO-177 Class ships will greatly improve the quality of boiler feedwater and, coupled with the coordinated phosphate method of boiler water treatment currently in use, will minimize waterside deposit formation. This presents an excellent opportunity (1) to extend the period between waterside cleanings beyond the 2,000 steaming hours currently required and (2) to reduce still further the man-hour burden associated with the cleaning of watersides.

Recent discussions with NAVSSES, Philadelphia, boiler code personnel and RSG, Norfolk, boiler inspectors confirm that a significant extension should be feasible; however, both maintain that a waterside inspection

requirement should be maintained at 2,000 operating hours and that the decision to extend the waterside hours beyond 2,000 operating hours should be made on the basis of that inspection. Section 221-2.109 of NSTM Chapter 221 clearly states that "Boilers shall not be steamed more than 2,000 hours between successive waterside inspection periods." However, it continues to cite the criteria by which the ship's engineer officer may evaluate past water chemistry and boiler blowdown records and may perform a waterside inspection. On the basis of these results, he is authorized to make a decision either to clean watersides or to extend the steaming hours for a period not to exceed an additional 2,000 operating hours. The applicable PMS maintenance requirement cards (MRCs) covering the inspection and cleaning of watersides include a note stating: "If boiler is on extended waterside steaming hours and conditions are satisfactory, no mechanical cleaning is necessary, omit Maintenance Requirement No. 2 (Clean Waterside Mechanically)." However, there are currently no extended waterside programs in effect. As a result, the option of not cleaning watersides at 1,800 to 2,000 operating hours does not exist in PMS. In addition, COMNAVSEASYSCOM message 110353Z, March 1981, pertaining to EDTA boiler waterside cleaning, states that EDTA cleaning after 1,800 to 2,000 hours of steaming is authorized for use *before* the 1,800-to-2,000-hour inspection. Therefore, the engineer officers' option to extend watersides on the basis of a satisfactory inspection as set forth in NSTM Chapter 221 no longer exists.

NAVSSES and COMNAVAIRPAC have been evaluating the possibility of extending the interval between waterside cleanings. The preliminary findings, which were based on evaluations of waterside conditions after water-jet cleaning, indicate that the interval can be extended after water-jet cleaning but not after EDTA cleaning. Because these are only preliminary findings, no specific extension has been recommended. The results of the NAVSSES evaluation are expected in early 1982.

In view of the recent improvements in boiler water treatment (coordinated phosphate treatment) and the authorization of shipalts that will improve the quality of boiler feedwater, it should be feasible to develop an extended waterside program, including inspection criteria, that will permit an engineer officer to exercise his options as specified in Section 221-2.109 of NSTM Chapter 221. The principal benefit to be derived from such a program will be a further reduction of PMS-related maintenance burdens, with an attendant increase in morale and man-hour availability for other priority work.

3.2.4.5 Recommendations for PMS-Related Maintenance

Recommendations for reducing the preventive maintenance burden associated with boiler waterside maintenance and improving long-term waterside material condition are presented in this section. For clarity and ease of presentation, the following recommendations are categorized by specific maintenance area:

- Boiler Lay-Up Procedures (Section 3.2.4.1)
  - Shipalts should be prepared to implement forced-hot-air lay-up capability on AFS, AOE, AOR, and AO-177 Class ships.

- A combination of hydrazine waterside and forced-hot-air fireside lay-ups should be implemented for ships in shipyards that use the hydrazine lay-up method.

- Waterside Cleaning (Section 3.2.4.2)

  - Ship's force personnel should inventory mechanical boiler waterside cleaning equipment at each SRA to ensure that a complete complement is maintained.

  - Ship's force personnel should ensure that all AFS, AOE, AOR, and AO-177 Class ships are provided with sufficient equipment, documentation, and training to effectively implement the EDTA waterside cleaning procedure.

- Feedwater Quality Improvement (Section 3.2.4.3). The following shipalts should be installed at the earliest opportunity:

  - Demineralizer system

    -- AFS-276K

    -- AOE-312K

    -- AOR-275K

  - Morpholine injection system

    -- AFS-283K

    -- AOE-319K

    -- AOR-282K

  Shipalts should be developed for the AO-177 Class ships.

- Extending Waterside Cleaning Interval (section 3.2.4.4). NAVSEASYSCOM Code 5222, in conjunction with NAVSSES Code 022E and Type Commanders, should develop the criteria for implementing an extended waterside program that will eliminate the *routine* requirement to clean watersides every 1,800 to 2,000 operating hours.

3.2.5 Boiler-Related Tests and Inspections

3.2.5.1 Discussion

There are numerous requirements for boiler tests and inspections. Some are required on a periodic basis while others are based on particular sets of circumstances. Chapter 221 of the NSTM describes the general test and inspection requirements for boilers and provides guidance for their accomplishment. Specific requirements for conducting periodic boiler tests and inspections are addressed in the PMS and in various implementation instructions promulgated by OPNAV and Type Commanders.

PMS requirements are set forth in MIPs applicable to specific boilers. Table 3-14 summarizes the MIPs applicable to the boilers installed in AFS-1, AOE-1, AOR-1, and AO-177 Class ships as of the third quarter of 1980. These MIPs have been used as a reference during the conduct of this analysis.

Table 3-14. PMS MAINTENANCE INDEX PAGE (MIP) APPLICABILITY FOR 600 PSI BOILERS INSTALLED ON AFS-1, AOE-1, AND AOR-1, AND AO-177 CLASS SHIPS

APL	Manufacturer	Applicable Hulls	Applicable MIP
021200180	Babcock & Wilcox	AFS-1, -2, and -3	F-001/110-89
021200186	Babcock & Wilcox	AFS-4, -5, -6, and -7	F-001/149-48
021450056 021450057	Combustion Engineering	AOE-1	F-001/127-30
021450061 021450062	Combustion Engineering	AOE-2	F-001/127-30
021450068 021450069	Combustion Engineering	AOE-3	F-001/127-30
021200187 021200188	Babcock & Wilcox	AOE-4	F-001/167-98
021550091 021550092	Foster-Wheeler	AOR-1 through -7	F-001/173-10
021450089 021450090	Combustion Engineering	AO-177 through -179	F-001/219-89

Specific boiler tests and inspections required by PMS and those which require off-ship assistance are summarized in Table 3-15. OPNAV Instruction 9221.1 of 8 January 1979 further establishes a policy for the conduct of formal inspections of all conventional main propulsion steam generating plants and auxiliary boilers in all U.S. Navy ships. It requires that all boilers be inspected by a certified steam generating plant inspector (SGPI) at intervals not to exceed 18 months. COMNAVSURFLANT message 070152Z, May 1980, provides additional implementation direction.

The PMS-required ultrasonic testing of piping systems and the periodic inspection of soot blower snap rings on applicable ships can both be accomplished by either an IMA or an industrial facility. However, NSTM Chapter 221, Section 221-2.339, indicates that the five-year boiler strength and integrity inspection *should be* performed while the ship is at a Navy shipyard. The apparent reason for this restriction is that if significant weld joint defects are encountered during the inspection, qualified personnel and facilities will be immediately available to accomplish the necessary repairs. If it is assumed that the five-year boiler strength and integrity inspection *requires* the ship's presence at an industrial facility, the requirement for this inspection becomes a significant consideration in determining when industrial availabilities must be scheduled.

On the basis of the results of this analysis, there is no evidence of overriding boiler maintenance considerations that would necessitate major

Table 3-15. SUMMARY OF PMS MAINTENANCE ACTIONS REQUIRING OUTSIDE (OFF SHIP) ASSISTANCE			
MIP	Required Action	Frequency	Recommended Level of Repair
F-001/110-89 F-001/127-30 F-001/149-48 F-001-165-10 F-001/173-10 F-001/210-89	Submit work request to authorized repair activity for inspection of boiler strength in accordance with NSTM 221-2.339,340.	5 years	Depot
	Request repair activity to ultrasonically test soot blower heads and piping, high-pressure drain piping from header to first valve, and surface and bottom blow piping from drum or header to skin of ship. Note: Accomplish during shipyard overhaul, or when piping damage is experienced, or when piping integrity is suspect.	ROH or R (See Note)	IMA or Depot
F-001/127-30 F-001/173-10 F-001/219-89	Request repair activity to inspect soot blower snap rings.	5 years	IMA or Depot

industrial-level boiler repairs as frequently as every five years. The analysis indicates that given the scheduling of brief periodic IMA and industrial availabilities during the operating cycle to perform routinely required boiler maintenance, there is no substantial evidence to support the need for major boiler overhauls at intervals of less than 10 years. If a boiler overhaul cycle of 10 years were adopted, either the five-year boiler strength and integrity inspections would have to be scheduled for accomplishment during one of the interim industrial availabilities or the requirement would have to be extended to agree with the revised overhaul cycle. If feasible, extension of the inspection interval would reduce the overall boiler maintenance costs.

It is suggested that NAVSEA and NAVSSES, Philadelphia, boiler codes review past data pertinent to the five-year strength and integrity inspections to determine whether significant problems have been encountered. On the basis of the results, a judgment could be made of the feasibility of extending the currently required five-year interval to ten years.

Written comments on the original version of this report received from NAVSSES Code 022E indicated that the feasibility of extending the interval between boiler integrity inspections has been considered: "There is no known background information to support extension of the 5-year boiler integrity inspection. Due to the nature of corrosion of pressure parts imbedded in refractory, coupled with the facts that some of these arrangements are not accessible to BTIU inspection and that severely thinned waterwall tubes have led to catastrophic failures in the past, doubling the

interval as proposed by the SEA is not warranted." The action identified in this comment satisfies the intent of the original recommendation. (For historical reasons, the discussion and original recommendation are left as originally stated.)

3.2.5.2 Recommendations

(The preceding paragraph states that the intent of the following recommendation has been satisfied by NAVSSES. The following recommendation is repeated only for historical purposes.)

It is recommended that for boiler-related tests and inspections, NAVSEA and NAVSSES, Philadelphia, boiler code personnel should conduct a review of past five-year boiler strength and integrity inspection results to determine the feasibility of extending the inspection interval to ten years.

The five-year boiler strength and integrity inspections should be conducted during industrial-level SRAs.

3.3 AO-177 CLASS TOP-FIRED BOILERS

The boilers installed on AO-177 Class ships are Combustion Engineering Type V2M-8 welded-waterwall boilers, known also as top-fired boilers because of the location of the burners in the roof of the furnace. There are significant differences in the design of these boilers and the design of the boilers installed in AFS-1, AOE-1, and AOR-1 Class ships that should minimize the corrective and preventive maintenance required during the operating life of the ships. These differences and their effects are described in the following sections.

3.3.1 Waterwall Construction of Top-Fired Boilers

The Type V2M-8 boilers installed in AO-177 Class ships are of waterwall construction, in which the spaces between the tubes in the three sides, floor, and roof of the boiler are closed by steel plate welded to both sides of the tubes. This waterwall construction forms a gas-tight seal around the furnace and eliminates the need for an inner casing. The boilers installed in the other three classes have brickwork and castable refractory to insulate the inner casing and protect the casing from the effects of the burning gases. Where there are projections or openings into the furnace, such as the burners or manhole accesses to the furnace, the waterwall tubes are bent around those areas and then rebent to reform the solid waterwall.

Castable refractory is used around each of the headers and the superheater floor to provide protection from the burning gases. Brickwork is installed in the roof and in the superheater floor; tiles are installed around each burner; and mineral fiber insulation is installed around the front, sides, and roof of the furnace and around the front, sides, uptakes, and the superheater floor in the remainder of the boiler. In the other boilers, brickwork and castable refractory form a significant portion of the interior of the boiler and furnace and are subject to the erosive and

burning effects of the burning gases. This has a significant effect on the corrective maintenance burden because brickwork and castable refractory must often be repaired or replaced. In the AO-177 Class ships, this replacement should be made at about the same frequency because of the life limitations of the materials, but it should incur a significantly lower maintenance burden because of the smaller amount of refractory installed in the boilers. In addition, the inspections and tests listed in NSTM Chapter 221 (Sections 221-2.339 and -2.340) will require that the castable refractory be removed from around the headers to determine if there is leakage around the joints of imbedded tubes when the boiler is subjected to the 150 percent boiler-design-pressure hydrostatic test. After the test, the castable refractory is replaced.

In view of the NAVSSES opinion (see Section 3.2.1.1) that burner tile and castable refractory will remain in acceptable condition for up to five years and the requirements for five-year boiler strength and integrity tests and inspections, burner tiles and castable refractory should be completely renewed at five-year intervals in conjunction with the strength and integrity tests and inspections. The remaining refractory should remain in an acceptable condition for up to 10 years. Because periodic inspections of firesides are required by PMS, refractory condition will be assessed frequently. Decisions to replace refractory prior to the end of its service life should be made on the basis of those inspections.

The effect of these recommendations will be, as it is for the other classes, to minimize unnecessary replacement of boiler refractory materials. In the AO-177 Class, there will also be a significant reduction in the overall labor burden to repair or replace refractory because smaller amounts of refractory will be installed in AO-177 Class boilers than in the other ships' boilers. Over the operating life of the AO-177 Class ships this lower burden will reduce maintenance costs and, considering the comparatively low maintenance man-hours available on these low-manning ships, will lessen the impact of needed preventive and corrective maintenance on ship personnel.

3.3.2 Steam Dump System and Safety Valve Maintenance

The steam dump system on AO-177 Class ships represents a significant change from the AFS-1, AOE-1, and AOR-1 (and other) classes in the design of safety valve subsystems, because it ties together the auxiliary exhaust system and the safety valves. On most steam-driven ships the auxiliary exhaust and safety valves are not directly connected. When the steam drum pressure exceeds the setpoint, safety valves lift (in prescribed order by lifting pressure) to bleed off excessive steam pressure. On the AO-177 Class ships there are connections between the auxiliary exhaust system and the steam drum, resulting in less wear on the safety valves. Figure 3-1 is a simple schematic diagram showing the connection between the affected portion of the auxiliary exhaust system and the steam drum.

The key elements in the steam dump system are the pressure sensors, which sense the auxiliary exhaust and steam drum pressures; and the dump valve between the steam drum and the auxiliary exhaust system. In normal operation, pressure sensor A controls auxiliary exhaust system pressure by

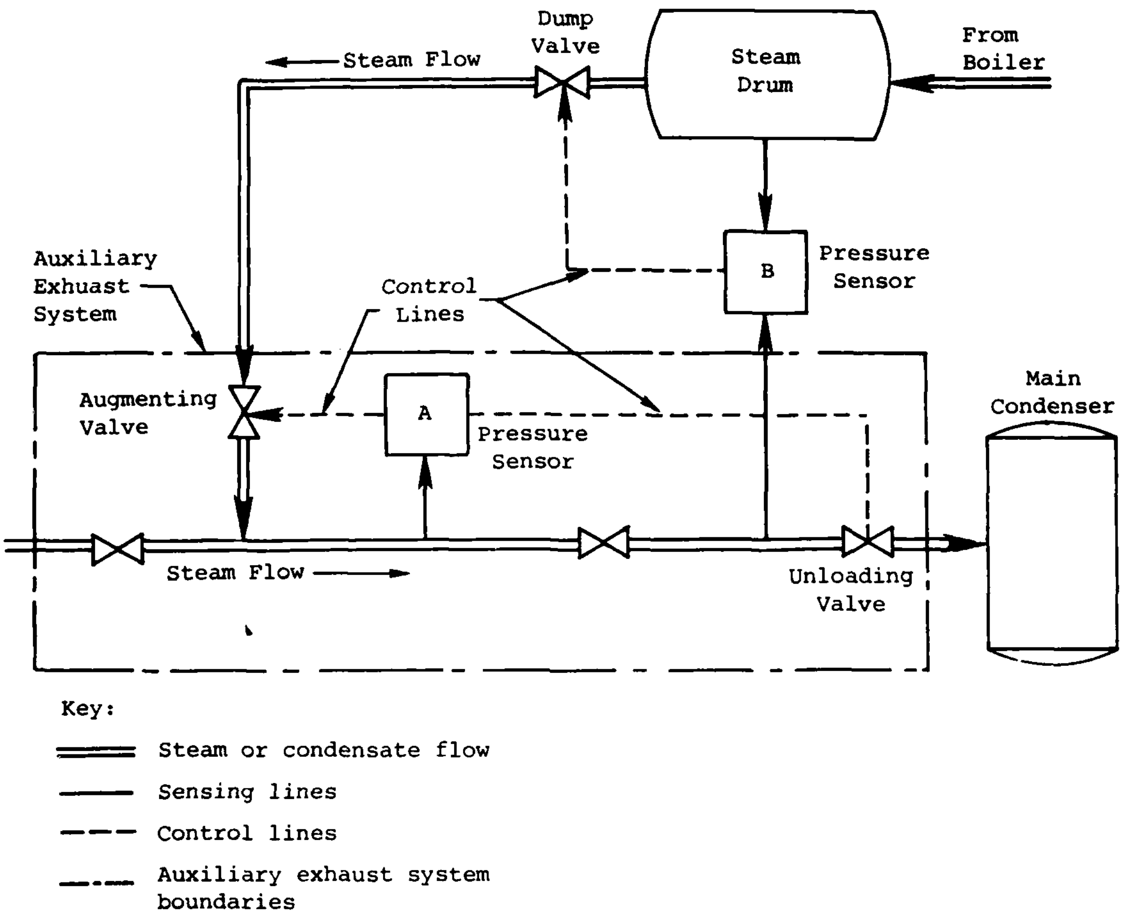

Figure 3-1. SCHEMATIC DIAGRAM OF STEAM DUMP SYSTEM ON AO-177 CLASS SHIPS

dumping steam to the main condenser when the pressure is too high and by adding augmenting steam when the pressure is too low. The steam systems on the other ships also work this way, and this operation is not unique to AO-177 Class ships. However, only AO-177 Class ships have pressure sensor B, which senses both auxiliary exhaust and steam drum pressure and works as follows: If auxiliary exhaust pressure is low, sensor B works with sensor A to provide augmenting steam to raise the auxiliary exhaust system pressure. Alternatively, if steam drum pressure becomes too high, sensor B opens the dump valve, dumping steam through reducers to the auxiliary exhaust system. When this happens, sensor A causes the excess steam in the auxiliary exhaust system to dump into the main condenser, relieving the excess pressure on the steam drum and on the auxiliary exhaust system.

Note that safety valves do not lift in this scenario. In the AFS-1, AOE-1, and AOR-1 Classes, the superheater pilot safety valve would lift when the drum pressure exceeded its setpoint. If drum pressure were near the setpoint, the valve would simmer or chatter and would wear to the point where it would not seal correctly. This behavior normally results in significant maintenance by ships' forces and by IMAs or depot-level activities for valve overhauls. The steam dump system averts this maintenance because it prevents the safety valves from simmering or chattering when drum pressure nears the setpoints by relieving drum pressure through the dump valve and auxiliary exhaust system. Pressure sensor B is set to open the dump valve before the setpoints are reached.

Although it is possible for the safety valves to lift if steam drum pressure rises even after the dump valve opens, in practice this is unlikely because the auxiliary exhaust system piping and the steam piping between the drum and the auxiliary exhaust system are large enough to handle the steam flow from the drum.

As stated in Section 3.2.2.2, the maintenance philosophy of safety valves has become run-to-failure with the establishment of CISCs. The combination of CISCs, deployed IMAs that are capable of overhauling safety valves, and some repair capability by ships' forces permits safety valve overhauls and repairs to be accomplished without yard availabilities. Therefore, there is no reason to schedule safety valve overhauls routinely. The presence of the steam dump system on AO-177 Class ships supports this position. Overhauls of safety valves should therefore not be scheduled on a regular basis during any depot-level availability.

3.4 MAINTENANCE STRATEGY

3.4.1 Discussion

The results of this analysis indicate that the current maintenance strategy employed for 600 psi boilers during the operating cycle (excluding ROH) is one of on-condition maintenance. The means for identifying required repairs is provided by the combination of periodic inspections of boiler watersides and firesides by ship's force personnel as required by PMS and the 18-month boiler inspections by certified steam generating plant inspectors as required by OPNAV Instruction 9221.1. Repairs identified as necessary are normally accomplished at the time of the inspection by ship's force personnel assisted as necessary by an IMA. Similarly, the material condition of boiler bottom and surface blow piping, soot blower piping, soot blower heads, high-pressure drain piping, and boiler tubes can be monitored through the use of ultrasonic and boiler tube sampling techniques. These techniques can be employed to trend degradation in boiler-related piping systems, soot blower heads, and boiler tube wall thickness; therefore, the need for replacement can be predicted well before failure.

The current PMS requirements specify ultrasonic testing of these piping systems and soot blower heads during overhaul but do not preclude its use during the operating cycle if the material condition of any system is suspect.

The British BTIU, an ultrasonic testing device, can also be used to monitor degradation in boiler tube wall thickness and to predict the need for major tube renewals well in advance of failure. Boiler accessory equipments, including valves, are routinely monitored for proper operation by watch station personnel and are repaired or replaced on an as-needed basis by ship's force or IMA personnel.

On the basis of the analysis performed, there is no evidence to indicate that boilers normally require major industrial-level overhauls at intervals of less than 10 years. The principal limiting factor is the need to renew inaccessible brick refractory located behind the sidewall and rearwall tubes and in the vicinity of the superheater and main generating bank. These renewals necessitate the removal of sections of inner and outer casings or numerous boiler tubes. The manpower and facilities required for this task dictate that it be accomplished at an industrial facility. Discussions with NAVSEACENLANT Code 710 personnel identified at least two cases in which ship's boilers have operated reliably for 10 years without major refractory renewals.

A review of past overhauls for AFS-1, AOE-1, and AOR-1 Class ships revealed that ship overhaul intervals have ranged from three and one-half years to five years. A review of the authorized SARPs for recent overhauls showed that large boiler repair packages were normally included. Discussions with COMNAVSURFLANT maintenance personnel disclosed that in the interest of obtaining a thorough ship overhaul and ensuring maximum reliability during the operating cycle, the trend is toward more extensive overhauls based on interpretation of policy rather than individual equipment needs. As a result, both boilers and some general categories of boiler-related equipment (e.g., burners and air registers, soot blower heads and elements, bottom blow valves, safety valves) are being routinely overhauled at ROH as a matter of convenience whether there is evidence of need or not. This results in numerous unnecessary repairs, a situation that is not consistent with the on-condition maintenance strategy employed during the operating cycle.

On the basis of this analysis, it has been determined that boilers generally do not wear out in the commonly accepted sense, because they have no moving parts. However, they do deteriorate over time as a result of corrosion, thermal stress, failure of support equipments, and damage attributable to personnel operating errors. The driving factors that dictate the need for major industrial-level boiler repairs (overhauls) have been determined to be complete brick refractory renewal, major air casing repairs, and major boiler tube renewals. The limiting factor is complete brick refractory renewal, and on the basis of the evidence presented in this report, the appropriate renewal interval is projected to be 10 years. There is no evidence to support the routine industrial-level overhaul of boilers at shorter intervals. Accordingly, the maintenance strategies described in the following paragraphs should be adopted for 600 psi boilers and boiler accessories installed in AFS-1, AOE-1, AOR-1, and AO-177 Class ships.

Boilers should continue to be maintained during the operating cycle (the period between industrial-level overhauls) by using an on-condition maintenance strategy. The results of PMS-required fireside and waterside inspections and OPNAV-required 18-month boiler inspections should be employed to identify necessary repairs. Repairs resulting from these inspections should be accomplished by ship's force personnel, with assistance as necessary from an IMA or industrial activity during an SRA.

Boiler bottom blow, surface blow, soot blower, and high-pressure drain piping and soot blower heads (wall thickness only) should also be maintained by using an on-condition maintenance strategy. A system should be developed that provides for the periodic ultrasonic testing of these systems during the operating cycle and for the trending of results. Necessary repairs and replacements should be projected on the basis of the trend analysis and planned for accomplishment during SRAs.

The need for major boiler tube renewals should be based on a trending of results from periodic BTIU inspections and analysis of tube samples taken at specified intervals. Appropriate intervals for BTIU inspections and tube sampling should be identified by cognizant Navy technical codes, and a system for trending results should then be developed and implemented. Major tube renewals should be scheduled to coincide with industrial-level boiler overhauls.

Boiler accessory equipments should be maintained on a run-to-failure basis during the operating cycle, with necessary repairs performed by ship's force or IMA personnel on an as-needed basis.

Major industrial-level boiler overhaul should be scheduled for accomplishment at intervals of 10 years. If a boiler overhaul cycle of 10 years is ultimately adopted, the routine overhaul of all burners and air registers, all soot blower heads and elements, and all main and auxiliary steam stops should be included. The routine industrial overhaul of bottom blow valves, gage glasses, and safety valves, even at this extended interval, is not warranted and therefore is not recommended for routine accomplishment.

3.4.2 Maintenance Strategy Recommendations

The following maintenance strategies for boilers and boiler accessory equipments installed on AFS-1, AOE-1, AOR-1, and AO-177 Class ships are recommended:

- Boilers should be scheduled for major industrial overhauls at intervals of ten years.
- During the operating cycle (between boiler overhauls), the following equipments, systems, and components should be maintained by using an on-condition maintenance strategy:
  - 600 psi boilers (including refractory, drums and headers, air casings, tubes, sliding feet, and economizers)

- • Boiler-related piping systems
  - -- Bottom blow piping
  - -- Surface blow piping
  - -- Soot blower piping
  - -- High-pressure drain piping
- • Soot blower heads (wall thickness only)

• The following boiler accessory equipments should be maintained by using a run-to-failure maintenance strategy:

- • Safety valves
- • Fuel oil burners and air registers
- • Soot blowers (operation only)
- • Gage glasses
- • Smoke indicators
- • Boiler-associated valves and valve operators

Implementation of these maintenance strategies will require the following actions:

- The development of a system that provides for the periodic ultrasonic testing of boiler-related piping systems, trending of results, and projection of repair requirements
- The identification of appropriate BTIU inspection and boiler tube sampling intervals by cognizant Navy technical codes and the development of a system for trending results and projecting the need for major tube renewals

CHAPTER FOUR

CONCLUSIONS AND RECOMMENDATIONS

4.1 CONCLUSIONS

The following significant conclusions resulted from this analysis:

- Boilers generally do not wear out in the commonly accepted sense, because they have no moving parts. However, they do deteriorate over time as a result of corrosion, thermal stress, failure of support equipments, and damage attributable to personnel operating errors.
- The principal factor limiting the interval at which boilers should be overhauled by an industrial facility is the total replacement of brick refractory. With the exception of catastrophic failures resulting from damage due to multiple tube ruptures or major flare-back, brick refractory should perform reliably, with only minor ship's force or IMA-level repairs, for up to 10 years.
- Boilers and boiler accessory equipments have traditionally been subjected to major industrial-level repairs in conjunction with ship overhauls at intervals ranging from three and one-half years to five years. However, there is no evidence from this SEA to support the need for performing industrial-level boiler overhauls at intervals of less than 10 years.
- During the operating cycle (between boiler overhauls), boiler and boiler accessory equipments are maintained by using the following maintenance strategies:
  - Boilers are maintained by using an on-condition maintenance strategy. Necessary repairs are identified through periodic boiler inspections specified by PMS and OPNAV Instruction 9221.1. All operating cycle repairs are normally accomplished by ship's force personnel, assisted as necessary by an IMA or by outside contractors.
  - Boiler accessory equipments (fuel oil burners, safety valves, soot blower heads and elements, gage glasses, smoke indicators, and bottom blow and general-purpose steam valves) are currently maintained according to a run-to-failure maintenance strategy. The need for repairs is determined by operating personnel as

part of their normal watch routine. Repairs are normally performed by ship's force personnel, assisted as necessary by an IMA or outside contractor on an as-needed basis.

4.2 RECOMMENDATIONS

Individual recommendations for scheduled corrective and restorative maintenance actions and maintenance strategy improvements for 600 psi boilers, boiler accessory equipments, and boiler-related valve and piping systems can be categorized as follows:

- Design improvements
  - Recommended shipalts, ordalts, and field changes
  - Recommended equipment redesign or replacement
- Maintenance strategy improvements
  - Depot maintenance requirements
  - IMA maintenance requirements
  - PMS changes
  - Policy
- Support improvements
  - ILS improvements
  - Maintenance capability improvements

Table 4-1 summarizes the recommendations resulting from this analysis. No recommendations regarding equipment redesign or PMS changes have been included in Table 4-1, since none were identified from the analysis as being necessary.

Table 4-1. SUMMARY OF RECOMMENDED ACTIONS FOR 600 PSI BOILERS ON AFS-1, AOE-1, AOR-1, AND AO-177 CLASS SHIPS

Component	Number	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Section Reference
		Design Improvements - Maintenance-Related ShipAlts			
Superheater Headers	1a.	Accomplish shipalt AOE-421D during ROH only for ships on which division plate attachment welds have extensive cracking, as determined by inspection. Otherwise, it is necessary only to repair the cracks.	Depot	-	3.2.1.2
	1b.	Accomplish shipalt AOR-117D during ROH only for ships on which the seal-welded superheater tube-to-header joints are not satisfactory, as determined by inspection. Replacement superheater headers for use in accomplishing this shipalt should be evaluated for the suitability of the gas tungsten arc-welded (GTAW) joint instead of the rolled joint before the GTAW process is used.	Depot	-	3.2.1.2
Boiler Tubes	2.	Accomplish shipalt AFS-236D on AFS-1, 5 & 7 during next ROH.	Depot	-	3.2.1.4
Sliding Feet	3.	Ensure that sliding foot movement indicators similar to that described in Figure 9-2 of NAVSEA 0951-LP-031-8010 are installed on all AFS, AOE, and AOR ships at the earliest opportunity.	IMA/Ship's Force	-	3.2.1.5
Fuel Oil Burners	4.	Schedule accomplishment of the following maintenance-related shipalts on all outstanding ships at the earliest opportunity: • AFS-154F • AOE-187F • AOR-132F • AFS-428D • AOE-484D	IMA/Ship's Force	-	3.2.2.1
Safety Valves	5.	Schedule accomplishment of the following shipalts at the earliest opportunity: • AFS-395K • AOE-448K • AOR-423K	Depot	-	3.2.2.2
Gage Glasses	6.	Cancel accomplishment of the following shipalts: • AFS-325K • AOE-375K • AOR-273K	Depot	-	3.2.2.4
Boiler Lay-Up	7.	Prepare shipalts to implement forced-hot-air lay-up capability on AFS, AOE, AOR, and AO-177 Class ships.	NAVSSES, Phila.	-	3.2.4.1
Feed Water Quality	8.	Install the following shipalts at the earliest opportunity and prepare shipalts for the AO-177 Class ships: • Demineralizer System •• AFS-276K •• AOE-312K •• AOR-275K	Depot	-	3.2.4.3
		• Morpholine Injection System •• AFS-283K •• AOE-319K •• AOR-282K	Depot	-	3.2.4.3
Bottom Blow Systems	9.	Install monel bottom blow systems at the earliest opportunity as specified by the following shipalts: • AFS-391K • AOR-420K • AOE-445K • AO-XXXK (unnumbered, in preparation)	Depot	-	3.2.3.4
		Maintenance Strategy Improvements - Depot Maintenance Requirements			
600 PSI Boilers	10.	Complete the following tasks during industrial level boiler overhauls:	Depot	10 years	
Refractory	**10a.**	**• Renew all castable and brick refractory.**			**3.2.1.1**
Drums & Headers	**10b.**	**• Remove, clean, inspect and repair steam drum internals.** **• Remove, inspect and repair/replace all handhole and manhole plates.** **• Repair handhole and manhole seating surfaces as necessary.**			**3.2.1.2**

(continued)

Table 4-1. (continued)

Component	Number	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Section Reference
		Maintenance Strategy Improvements - Depot Maintenance Requirements (continued)			
Drums & Headers (continued)	10b.	• Remove, inspect, repair, reinstall, and hydrostatically test desuperheater elements.			
		• Accomplish other drum and header repairs identified as necessary by the pre-overhaul and start-of-overhaul boiler inspections.			
Air Casings	10c.	• Repair and re-gasket all access doors and panels.			3.2.1.3
		• Replace all missing or stripped boiler casing studs, bolts, and dogs.			
		• Renew deteriorated sections of the air casing as determined necessary by pre-overhaul and start-of-overhaul boiler inspection.			
		• Conduct post-repair air casing tightness test to 15 inches of water.			
Boiler Tubes	10d.	• Renew all plugged tubes.			3.2.1.4
		• Renew boiler tubes as indicated necessary by BTIU inspection and tube sample analysis performed prior to overhaul.			
Sliding Foot	10e.	• Repair sliding feet as indicated necessary by pre-overhaul and start-of-overhaul boiler inspections.			3.2.1.5
Economizers	10f.	• Renew all plugged economizer elements.			3.2.1.6
		• Accomplish economizer repairs as indicated necessary by pre-overhaul and start-of-overhaul boiler inspections.			
		• Perform post-repair hydrostatic test of economizers <u>only</u> if repairs have been performed.			
Boiler Accessory Equipment	11.	Accomplish the following tasks during industrial-level boiler overhauls.	Depot	10 Years	-
Fuel Oil Burners	11a.	• Class "B" overhaul all burners and air registers.	Depot	10 years	3.2.2.1
Safety Valves	11b.	• None	-	-	3.2.2.2, 3.3.2
Soot Blowers	11c.	• Remove, inspect, preserve, and repair or replace as required all soot blower elements.	Depot	10 years	3.2.2.3
Gage Glasses	11d.	• None	-	-	3.2.2.4
Smoke Indicators	11e.	• None	-	-	3.2.2.5
Main and Auxiliary Steam Stop and Guarding Valves	12.	*Accomplish the following tasks during industrial-level SRAs:*			
		• Accomplish class "B" overhaul. Use staggered overhaul concept to distribute overhauls across multiple industrial availabilities during the operating cycle rather than having all overhauls performed during ROH.	Depot	SRA/5 years	3.2.3.1
		• For ships on a phased maintenance program, schedule class "B" overhaul of main and auxiliary steam stop and guarding valves associated with the particular boiler scheduled for maintenance.	Depot	-	3.2.3.1

(continued)

Table 4-1. (continued)

Component	Number	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Section Reference
		Maintenance Strategy Improvements - Depot Maintenance Requirements (continued)			
Refractory	13.	• Renew all castable refractory and burner tile.	Depot	5 years	3.2.1.1
600 PSI Boiler	14.	• Accomplish 5 year boiler strength and integrity inspection. Make repairs indicated necessary.	Depot	5 years	3.2.1.1
600 PSI Boiler	15.	• Accomplish specific class "C" repairs indicated necessary by most recent boiler inspection and ship's CSMP.	Depot	SRA	3.3
Boiler Accessory Equipments	16.	• Accomplish specific Class "C" repairs indicated necessary by most recent boiler inspection and ship's CSMP.	Depot	SRA	3.3
Boiler-Related Piping Systems (Bottom Blow, Surface Blow, Soot Blower and HP Drains)	17.	• Accomplish repairs identified as necessary from trend analysis of periodic UT results.	Depot	SRA	3.2.3.4
		Maintenance Strategy Improvements - IMA Maintenance Requirements			
600 PSI Boilers, Boiler Accessories, and Boiler-Related Piping and Valves	18.	Assist ship's force personnel as required in performing necessary repairs during the operating cycle.	IMA	As re-quested	3.3.1
Boiler Tubes	19.	Perform BTIU inspection and remove boiler tube sample.	IMA	To be de-termined	3.2.1.4 & 3.3.1
Economizer "U" Bends	20.	Ultrasonically test a representative number of economizer "U" bends.	IMA	6 mos. prior to ROH	3.2.1.6
Boiler Blow, Soot Blower and H.P. Drain Piping and Soot Blower Heads	21.	Perform periodic ultrasonic tests.	IMA	To be de-termined	3.2.3.4
		Maintenance Strategy Improvements - Policy			
600 PSI Boilers, Boiler Accessories, and Boiler-Related Valve and Piping	22.	Schedule boilers for industrial-level overhauls at intervals of 10 years.	Depot	10 years	3.3.1
	23.	During the operating cycle, maintain the following equipments, systems, and components using an "on condition" maintenance strategy: • 600 PSI boilers • Boiler-related piping systems •• Bottom blow piping •• Surface blow piping •• Soot blower piping •• High pressure drain piping • Soot blower heads (wall thickness only)	-	-	3.3.1

(continued)

Table 4-1. (continued)

Component	Number	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Section Reference
		Maintenance Strategy Improvements - Policy (continued)			
600 PSI Boilers, Boiler Accessories, and Boiler-Related Valve and Piping (continued)	24.	During the operating cycle, maintain the following equipments using a "run-to-failure" maintenance strategy: • Safety valves • Fuel oil burners and air registers • Soot blowers (operation only) • Gage glasses • Smoke indicators • Boiler-associated valves and valve operators (except main and auxiliary steam stops and guarding valves).	-	-	3.3.1
Main and Auxiliary Steam Stops and Guarding Valves	25.	Class "B" overhaul at 5-year intervals. Adopt a "staggered" overhaul policy.	Depot	5 years	3.2.3.1
600 PSI Boilers	26.	Conduct 5-year boiler strength and integrity inspection during industrial-level SRAs.	Depot	5 years	3.2.5.2
Bottom Blow, Surface Blow, Soot Blower, and H.P. Drain Piping and Soot Blower Heads	27.	Develop a system that provides for the periodic *UT of boiler*-related piping systems and soot blower heads and for the trending of results and projection of repair/renewal requirements. • Perform a baseline ultrasonic test of bottom blow, surface blow, soot blower, and H.P. drain piping on all AFS-1, AOE-1 and AOR-1 Class ships to establish current material condition.	-	-	3.2.2.3, 3.2.3.4 3.3.1 3.2.3.4
		• Develop retest schedules for individual hulls on the basis of baseline test results to establish repair/renewal requirements and intervals.	-	-	3.2.3.4
Boiler Tubes	28.	Cognizant Navy boiler code personnel identify appropriate BTIU inspection and boiler tube sampling intervals and develop a system for trending results and projecting the need for major tube renewals.	-	-	3.2.1.4, 3.3.1
Bottom Blow Valves	29.	Fully investigate the potential benefits to be derived from "staggering" bottom blow valve overhauls during the operating cycle and implement a "staggered" bottom blow valve overhaul policy if warranted.	-	-	3.2.3.2
Welded-In Valves	30.	TYCOMs emphasize the performance of in-place repairs of welded-in valves when possible to reduce cost and system downtime.	-	-	3.2.3.1
Boiler Lay-Up	31.	Implement a combination of hydrazine waterside and forced-hot-air fireside lay-ups for ships in shipyards that use the hydrazine lay-up method.	-	SRA/ROH	3.2.4.1
Waterside Cleaning	32.	NAVSEASYSCOM Code 5222, in conjunction with NAVSSES Code 022E and Type Commanders, develop the criteria for and implement an extended waterside program that will eliminate the routine requirement to clean watersides every 1800 to 2000 operating hours.	-	-	3.2.4.4

(continued)

Table 4-1. (continued)

Component	Number	Recommendation/Maintenance Action	Level of Maintenance	Periodicity of Maintenance	Section Reference
		Support Improvements - ILS Improvements			
Yarway 2500 PSI	33.	Ensure that applicable boiler technical manuals are modified to include sections detailing proper repair procedures for the Yarway 2500 PSI gage glass. This recommendation applicable only if shipalts AFS-325K, AOE-375K, and AOR-273K are accomplished.	-	-	3.2.2.4
	34.	Ensure that all necessary special repair tools are provided to ship's force as part of the Yarway 2500 PSI shipalt implementation (AFS-325K, AOE-375K, AOR-273K) if it is accomplished.	-	-	3.2.2.4
Bottom Blow Valves	35.	Provide ship's force with a minimum of six spare bottom blow valves to be carried as operating space spares.	-	-	3.2.3.2
Mechanical Boiler Waterside Cleaning Equipment	36.	Ship's force personnel should inventory mechanical boiler waterside cleaning equipment at each SRA to ensure that a complement is maintained.	Ship's Force	SRA	3.4.2.4
EDTA Implementation	37.	Ensure that all AFS, AOE, AOR, and AO-177 Class ships are provided with sufficient equipment, documentation, and training to effectively implement the EDTA waterside cleaning procedure.	-	-	3.4.2.4
Pressure Seal Bonnet Valves	38.	Establish procedure to ensure that changes in internal dimensions of pressure seal bonnet valves are documented and appropriate seal ring allowance changes are made.	-	-	3.2.3.1
Pressure Seal Bonnet Valves	39.	COMNAVSEASYSCOM repromulgate NAVSEA Notice 9505 to ensure its continued availability and effectiveness until revised NSTM Chapter 505 and Valve Manual, NAVSEA 9253-AD-MMO-010, 020, 030 (3 Vols.) are provided.	-	-	3.2.3.1
		Support Improvements - Maintenance Capability Improvements			
Valve Repair and Test Facility	40.	Fully investigate the benefits to be gained by installing valve repair and test facilities on all AFS-1, AOE-1, AOR-1, and AO-177 ship classes. Develop appropriate shipalts to provide this capability if warranted on the basis of the investigation results.	-	-	3.2.3.2

APPENDIX A

SYSTEM BOUNDARIES FOR 600 PSI BOILERS

This appendix presents the boundaries for the 600 psi boiler system, as provided in the Propulsion Boiler Repair Inspection Requirements (taken from Fleet Machinery Notes, Volume 15, Number 1, May 1980). This document was used as the primary reference source in establishing the boundaries for this analysis. The 600 psi boiler system boundaries include all headers, water drums, and bottom blow drain nozzles to the first joint.

The associated equipments included within the boundaries for 600 psi boilers are as follows (an asterisk denotes those major components which were analyzed and discussed in this report):

- Air preheaters
- Boiler casing*
- Burners*
- Casing skirts*
- Draft indicators
- Drains*
- Economizers*
- External fittings
- Foundations
- Furnace lighting tube fittings
- Gages/thermometers/instrumentation
- Inner/outer burner plates
- Inspection hole fittings
- Internal desuperheaters*
- Lubricator - air-operated
- Operating gear
- Panels*
- Refractory*
- Safety valve easing gear
- Safety valves*
- Sediment strainers
- Sliding feet*
- Smoke indicators*
- Soot blowers*
- Steam drum insulation
- Superheaters*
- Tubes*
- Vents
- Water level indicators*

The following systems or equipments are not included within the boundaries for 600 psi boilers:

- Automatic boiler controls
- Automatic propulsion control system
- Alarm, safety, and warning systems
- Auxiliary boilers
- Auxiliary steam system (within machinery spaces)
- Main steam piping (non-nuclear)
- Uptakes and baffles (inner casing)

APPENDIX B

600 PSI BOILER INSTALLATION CONFIGURATIONS FOR AFS-1, AOE-1, AOR-1, AND AO-177 CLASS SHIPS

The major components of the 600 psi boilers on ships of the AFS-1, AOE-1, and AOR-1 Classes discussed in this report are listed in Table B-1. The major components for the top-fired boilers on AO-177 Class ships are listed in Table B-2. The data provided in the tables were obtained from various sources, including Type Commander's COSAL, Atlantic and Pacific Fleets, reported MDS data, and APLs that support individual equipments. Not all configurations could be identified, and an element of engineering judgment was used in cases of conflicting information. These tables represent the best estimate of current configurations.

Table B-1. CONFIGURATIONS FOR AFS-1, AOE-1, AND AOR-1 PROPULSION BOILER INSTALLATIONS (MAJOR COMPONENTS ONLY)

Nomenclature	APL/CID	AFS-1	AFS-2	AFS-3	AFS-4	AFS-5	AFS-6	AFS-7	AOR-1	AOR-2	AOR-3	AOR-4	AOR-5	AOR-6	AOR-7	AOE-1	AOE-2	AOE-3	AOE-4
		Quantity by Hull Number																	
Main Boilers																			
Babcock & Wilcox	021200180	3	3	3															
Babcock & Wilcox	021200181				3	3	3												
Foster-Wheeler	021550091								3	3	3	3	3	3	3				
Foster-Wheeler	021550092																		
Combustion Engineering	021450056															2			
Combustion Engineering	021450057															2			
Combustion Engineering	021450061																2		
Combustion Engineering	021450062																2		
Combustion Engineering	021450068																	2	
Combustion Engineering	021450069																	2	
Babcock & Wilcox	021200187																		2
Babcock & Wilcox	021200188																		2
Fuel Oil Burners																			
Modified Iowa	300020114				9	9	9	9											
Todd-CEA, Model D-20	300080098	9	9	9															
Todd-CEA, Model D-20(LH)	300080120								6	6	3	6	6	6					
Todd-CEA, Model D-20(RH)	300080121								3	3	6	3	3	3					
Todd-CEA, Model D-20(RH)	300080137														3				
Todd-CEA, Model D-20(LH)	300080138														6				
Todd-CEA, LVC4M(RH)	300080091															2			
Todd-CEA, LVC4M(LH)	300080092															2			
Todd-CEA, LVC4M	300080086															16			
Todd-CEA, LVS4M	300080110																16		
Todd-CEA, LVS4M(RH)	300080111																2		
	300080112																2		

(continued)

Table B-1. (continued)

Nomenclature	APL/CID	AFS-1	AFS-2	AFS-3	AFS-4	AFS-5	AFS-6	AFS-7	AOR-1	AOR-2	AOR-3	AOR-4	AOR-5	AOR-6	AOR-7	AOE-1	AOE-2	AOE-3	AOE-4
		Quantity by Hull Number																	
Todd-CEA, LVS4M	300080107																	16	
B&W, Modified 3M	300020115																		20
Safety Valves																			
Drum safety (consolidated)	882170316	6	6	6	6	6	6	6											
Superheater Safety (consolidated)	882170317	3	3	3	3	3	3	3											
Drum Safety (Crosby)	882170340								6	6	6	6	6	6	6				
Superheater Safety (Crosby)	882170342								3	3	3	3	3	3	3				
Superheater Safety (Crosby)	882170344								3	3	3	3	3	3	3				
Drum Safety (Crosby)	882170280															12	12	12	
Pilot (Crosby)	882170281															4	4	4	
Superheater Safety (Crosby)	882170282															4	4	4	
Drum Safety (Consolidated)	882170367																		12
Superheater Safety (consolidated)	882170368																		4
Pilot (consolidated)	882170369																		2
Pilot (consolidated)	882170370																		2
Soot Blower Heads																			
CCW, 170°, Chain Driven	813020213	3	3	3															
CW, 360°, Chain Driven	813020214	18	18	18															
CW, 360°, Air Motor Driven	813020279							21											
CCW, 170°, Air Motor Driven	813020280							3											
Stationary	813020281							6											
CW, 360°, Air Motor Driven	813020276				18	18	18												
CCW, 170°, Air Motor Driven	813020277				3	3	3												
Stationary	813020278				6	6	6												
CCW, 360°, Chain Driven	812030065								3	3	3	3	3	3	3				
CW, 240°, Chain Driven	813030066								18	18	18	18	18	18	18				

(continued)

AD-A114 724 ARINC RESEARCH CORP ANNAPOLIS MD F/G 13/10

SYSTEM ENGINEERING ANALYSIS OF 600 PSI BOILERS INSTALLED ON AFS--ETC(U)

APR 82 C E WILSON, C P BEYERS N00189-81-D-0126

UNCLASSIFIED 2656-01-6-2681 NL

2 of 2

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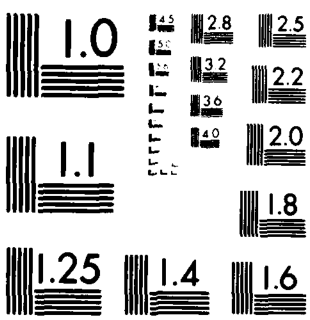

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963 A

Table B-1. (continued)

Nomenclature	APL/CID	AFS-1	AFS-2	AFS-3	AFS-4	AFS-5	AFS-6	AFS-7	AOR-1	AOR-2	AOR-3	AOR-4	AOR-5	AOR-6	AOR-7	AOE-1	AOE-2	AOE-3	AOE-4
		Quantity by Hull Number																	
CW	813030039															8	4	4	
CW	813030040															20	20		
CCW, 360°	813030051																4	4	
CW	813030058																	20	
CW	813020264																		4
CW, 335°	813020265																		12
CW, 150°	813020266																		4
CW, 310°	813020267																		8
CW, 310°	813020268																		8
Boiler Gage Glasses																			
Diamond	450010045	3																	
Jerguson (LH)	450020252			3	3	3	3	3											
Jerguson (RH)	450020253																		
Diamond	450010043		3																
Yarway (RH)	450030025								2	1	2	2	1	1	1			2	2
Yarway (LH)	450030026								1	2	1	1	2	2	2			2	2
Diamond (RH)	450010047																2		
Diamond (LH)	450010048																2		
Jerguson (LH)	450020180															2			
Jerguson (RH)	450020181															2			
Remote Liq-Level Ind.																			
Yarway	384030036			3	3	3	3	3											
Yarway	384030037			3	3	3	3	3											
Yarway	384030043			3	3	3	3	3											
Yarway	384030044	6	6																

(continued)

Table B-1. (continued)

Nomenclature	APL/CID	AFS-1	AFS-2	AFS-3	AFS-4	AFS-5	AFS-6	AFS-7		AOR-1	AOR-2	AOR-3	AOR-4	AOR-5	AOR-6	AOR-7		AOE-1	AOE-2	AOE-3	AOE-4
		Quantity by Hull Number																			
Yarway	384030046	3																			
Yarway	384030048		3																		
Yarway	384030054									6	6	6	6	6	6	6					
Yarway	384030004																				*
Yarway	384030055																			*	*
Yarway	384030022																	*			
Yarway	384030059																				*
Smoke Indicators																					
Diamond Pwr. Spec. Corp.	382010002	3	3																		
Robert H. Wager Co.	382030009			3	6	6	6	6		3	3	3	3	3	3	3					
Robert H. Wager Co.	382030010																	4	4	4	4

*AOE-1 Class remote liquid level indicator configurations could not be determined.

Table B-2. CONFIGURATION FOR AO-177 CLASS PROPULSION BOILER MAJOR COMPONENTS

Nomenclature	APL/CID	Quantity		
		AO-177	AO-178	AO-179
Combustion Engineering	021450089	1	1	1
Main Boilers	021450090	1	1	1
Fuel Oil Burner	300080146	4	4	4
Drum Safety Valve	882170340	2	2	2
Drum Safety Valve	882170404	2	2	2*
Pilot Superheater Safety Valve	882170356	2	2*	2
Superheater Safety Valve	882170347	2	2	2
Liquid Level Indicator	450010033			1
Liquid Level Indicator	450030032	1	1	1
Liquid Level Indicator	450030033	1	1	
Smoke Indicators	382030017B	2	2	2
Soot Blower System	813030100	2	2	2*
Remote Liquid Level Indicator - RH	384030100	1	1	1*
Remote Liquid Level Indicator - LH	384030101	1	1	1*

*Estimated configuration.

APPENDIX C

CASREP SUMMARY

Table C-1 summarizes by ship class the CASREPs reported against 600 psi boilers and boiler accessory equipments on AFS-1, AOE-1, and AOR-1 Class ships during the data period from 1 January 1977 through 30 June 1980. CASREPs reported for AO-177 during the period 1 January 1981 through 2 July 1981 were also reviewed. A total of 135 CASREPs were reported. The associated severity codes are as follows:

- Minor degradation in mobility (C-2) 103
- Major degradation in mobility (C-3) 22
- Total loss of mobility (C-4) 10

Of the 10 CASREPs reporting severity codes of C-4, 7 CASREPs represented those failure modes which caused all installed boilers to be unusable [i.e., remote boiler water level indicators out of calibration on all boilers (one CASREP), erroneous readings from remote boiler water level indicators (one CASREP), concurrent renewal of refractory on all boilers (three CASREPs), and failure or suspected deterioration of bottom blow piping (two CASREPs)]. The remaining three C-4 CASREPs were for seal ring leaks in the main or auxiliary guarding valves (two CASREPs) and one for leakage of a desuperheater and an economizer weld joint.

Because only one CASREP was submitted by ships of the AO-177 Class, no table was prepared for that class. The single CASREP had a severity of C-4 and reported 759 hours of downtime awaiting maintenance. There was no supply downtime.

The total downtime reported for all CASREPs was 29,434 hours -- 25,568 for maintenance and 3,866 for supply actions. Only eight CASREPs reported downtime awaiting supply action.

Table C-1. CASREP SUMMARY BY SHIP CLASS FOR 600 PSI BOILERS AND ACCESSORY EQUIPMENTS									
Equipment Nomenclature and Failure Mode	AFS-1 Class			AOE-1 Class			AOR-1 Class		
	Number of CASREPs		Percentage of Total	Number of CASREPs		Percentage of Total	Number of CASREPs		Percentage of Total
	By Failure Mode	By Equipment		By Failure Mode	By Equipment		By Failure Mode	By Equipment	
<u>Boilers</u>		12	25.5		20	48.8		14	30.4
Ruptured generating & screen tubes	3			4			3		
Economizer leaks and tube ruptures	2			0			0		
Leaking or blistered tubes	2			2			1		
Ruptured superheater tubes	0			6			0		
Leaking or blistered superheater tubes	1			3			4		
Cracks or pinholes in superheater headers	2			3			2		
Desuperheater leaks	1			1			0		
Leaking header handhole plates	0			0			1		
Cracked superheater support lug	0			1			0		
Air casing	0			0			2		
Fuel oil burner leaks	1			0			1		
<u>Auxiliary Equipment</u>		14	29.8		7	17.1		12	26.1
Automatic boiler controls		6			2			8	
Soot blowers		1			0			0	
Flame scanners		2			0			0	
Sample coolers		8			1			0	
Thermometers		0			1			0	
Boiler water level indicators		1			1			2	
Safety valves and escape piping		4			2			2	
<u>Valves and Piping</u>		11	23.4		11	26.8		16	34.8
Main steam stops and bypass valves		5			2			5	
Seal ring leaks		1			1			0	
Bottom and surface blow valves		1			0			7	
Fuel oil control valves		1			0			1	
Gasket and flange leaks		1			1			1	
Bottom blow piping		1			3			1	
Soot blower piping		1			0			1	
Drain lines and valves		0			4			0	
<u>Nonfailure</u>		7	14.9		1	2.4		0	0.0
<u>Personnel-Operating Errors</u>		3	6.4		2	4.9		4	8.7
Total CASREPs		47	100.0		41	100.0		46	100.0

APPENDIX D

SUMMARY OF BOILER-RELATED SHIPALTS FOR AFS-1, AOE-1, AND AOR-1 CLASS SHIPS

Tables D-1, D-2, and D-3 summarize the boiler-related shipalts for AFS-1, AOE-1, and AOR-1 Class ships, respectively. This information was obtained from the applicable ShipAlt Information Manuals and the ShipAlt Management Data Information System (SAMIS).

Table D-1. SUMMARY OF BOILER-RELATED SHIPALTs FOR AFS-1 CLASS SHIPS

Ship Alt	Title	Status by Ship Class							12/10/80 Included in Current AMT*
		AFS-1	AFS-2	AFS-3	AFS-4	AFS-5	AFS-6	AFS-7	
070D	Desuperheater removal/installation rig	C	C	C	P	C	A	C	No
091D	Main boiler inspection ports	C	C	C	C	1	2	C	No
154F	Todd atomizing system-"O" ring packing	C	C	C	N	N	N	N	No
220D	Modify steam atomizing control system	A	A	A	N	N	N	N	No
236D	Boiler tube stiffening devices	A	C	N	N	A	N	A	No
239D	Install NAVJET burner system	C	A	A	N	N	N	N	No
306D	Upper superheater cavity access door	2	A	C	A	A	A	A	No
322D	Modify automatic combustion control	2	C	C	N	N	N	N	No
325K	Install Yarway 2500 PSI boiler water gage	2	2	A	C	1	2	5	Yes
326	Install Barton RWCI/W325	2	C	A	C	1	2	C	Yes
327K	Replace automatic boiler control system	A	6	A	N	N	N	N	Yes
336F	Double handle safety shut-off	C	A	N	N	N	N	N	No
350F	Install LP air to #1 burner	N	N	A	5	C	A	C	No
355	Low pressure drain orifice	2	C	C	C	1	6	C	Yes
372K	Install superheater temp. indicating system	2	C	A	A	1	2	C	Yes
388K	Replace feedwater control system transmitter	N	N	N	5	5	5	5	Yes
391K	Install monel bottom blow system	A	A	A	5	A	A	5	Yes
395K	Replace boiler safety valve system	A	A	A	A	A	A	A	Yes
428D	Boiler burner seals replacement	N	N	N	A	5	5	A	No
431	Feed pump control system mod	A	A	A	N	N	N	N	No
349D	Replace steam flow and feed flow transmitters	A	4	A	A	6	5	A	No
276K	Install demineralizer system	2	4	A	5	4	6	5	Yes
283K	Install morpholine injection system	2	4	A	5	4	6	5	Yes
339F	Boiler water sample coolers	A	C	C	A	4	1	A	No
208D	H.P. drain system - install drain orifices	C	P		C	C	A	P	No
354D	Install superheater drain orifices	A	C	C	C	C	C	A	No

Legend:

C = Complete   A = Applicable   Blank = No status
P = Partial   N = Not applicable

Numbers represent year programmed; 1 through 9 represent last digit of years 1981 to 1989.

*AMT dated 10 December 1980.

Table D-2. SUMMARY OF BOILER-RELATED SHIPALTs FOR AOE-1 CLASS SHIPS

Ship Alt	Title	Status by Ship Class				12/10/80 Included in Current AMT*
		AOE-1	AOE-2	AOE-3	AOE-4	
187F	Todd atomizer system-"O" ring packing	A	C	A	N	No
189D	Modifications to automatic combustion controls	C	N	5	N	No
239D	Modify steam atomizing control system	N	C	5	N	No
248D	Modifications to superheater	C	N	N	N	No
250D	Boiler low-pressure air for atomization	N	C	A	N	No
252D	Relocate boiler gage glasses	N	N	N	2	No
256D	Modify boiler fuel control valve arrangement	N	2	5	2	No
269D	Install NAVJET burner system	6	C	9	N	No
278D	Access to boiler brick pans	C	C	A	N	No
323K	Install S/H temperature indicating system	1	2	5	2	Yes
374K	Automatic boiler control system modifications	N	2	5	2	Yes
375K	Install Yarway 2500 PSI boiler water gage	A	A	A	A	Yes
376	Install Barton RWLIs**	A	A	A	A	Yes
396F	Double handle safety shut-off	1	2	5	N	No
398F	Replace superheater actuator line	1	2	A	A	No
403	Install low-pressure drain orifice	1	2	5	2	Yes
421D	Superheater header floating diaphragm	C	2	5	N	No
426D	Filter for Barton transmitter	5	N	N	N	No
445K	Monel bottom blow system	6	A	5	7	Yes
448K	Replace boiler safety valve system	A	A	A	A	Yes
449D	Automatic boiler control system					No
453	Replace boiler header FOQC valves	A	A	A	A	Yes
477D	Remove boiler retractable soot blower	6	7	A	A	No
484D	Boiler burner seals replacement	6	7	A	A	No
312K	Install demineralizer system	1	2	5	2	Yes
319K	Install morpholine injection system	1	2	5	2	Yes
397F	Boiler water sample cooler	C	2	A	A	No

Legend:

C = Complete A = Applicable Blank = No status
P = Partial N = Not applicable

Numbers represent year programmed; 1 through 9 represent last digit of years 1981 to 1989.

*AMT dated 10 December 1980.
**SAMIS indicates that this alteration has been suspended.

Table D-3. SUMMARY OF BOILER-RELATED SHIPALTS FOR AOR-1 CLASS SHIPS

Ship Alt	Title	Status by Ship Class							12/10/80 Included in Current AMT*
		AOR-1	AOR-2	AOR-3	AOR-4	AOR-5	AOR-6	AOR-7	
117D	Replace main boiler superheater header	4	A	A	A	C	A	N	No
120D	Main boiler air box access	A	A	A	A	A	A	N	No
132F	Todd automization system-"O" ring packing	C	A	C	C	C	A	N	No
144D	Superheater protection steam piping mods	C	C	C	6	C	3	C	No
186D	Mods to ACC system	A	A	A	A	A	A	A	No
209D	Boiler superheater header Mod	C	C	C	C	C	3	N	No
225D	Boiler - LP air for atomization	C	A	C	C	C	C	N	No
253D	Install NAVJET burner system	C	5	C	C	C	3	N	No
282K	Install morpholine injection system	4	5	5	1	2	3	3	Yes
275K	Make-up feed water demineralizer system	4	5	5	1	2	3	3	Yes
310D	Relocate boiler surface blow valve	C	C	A	6	C	3	C	No
313D	Main boiler foundation mods	C	N	C	C	C	C	A	No
314F	ACC bias station poppet valve mod	C	C	C	A	C	A	8	No
266D	Install high-pressure drain system orifices	C	C	C	6	C	3	C	No
336D	Install additional high-pressure drain orifices	C	A	A	A	C	A	3	No
347K	ACC system modifications	4	5	5	1	2	3	3	Yes
366D	Replace superheater actuator line	A	5	A	6	2	3	3	No
381	Low pressure drain orifices	4	5	C	6	2	3	3	Yes
408D	Install thermometer in steam atomization line	4	A	A	A	A	A	3	No
420K	Monel bottom blow system	4	5	5	6	2	3	A	Yes
423K	Replace boiler safety valve system	A	A	A	A	A	A	A	Yes
457D	Remove boiler retractable soot blower	A	A	A	A	7	A	8	No
471D	Fuel oil atomizer steam separators								
475D	Boiler air preheater mod	A	A	A	A	A	A	N	No
491	Moisture-free atomizing steam system	A	A	A	A	A	A	A	No
272	Install BARTON remote water level indicator	A	A	C	A	A	A	A	Yes

Legend:

C = Complete A = Applicable Blank = No status
P = Partial N = Not applicable

Numbers represent year programed; 1 through 9 represent last digit of years 1981 to 1989.

*AMT dated 10 December 1980.

APPENDIX E

AUTHORIZATION OF EDTA BOILER CLEANING PROCEDURES

This appendix reproduces the COMNAVSEASYSCOM messages that authorize EDTA boiler waterside cleaning procedures for fleet use.

ROUTINE

R 122140Z FEB 81

FM COMNAVSEASYSCOM WASHINGTON DC

SUBJ: EDTA BOILER WATERSIDE CLEANING METHOD, IMPLEMENTATION OF

TO USS BROOKE
USS PATTERSON
USS BREWTON
AIG 373

XMT USS AINSWORTH
USS BARRY
USS CAPODANNO
USS CONNOLE
USS COONTZ
USS DAVIS
USS EDSON
USS FORREST SHERMAN
USS LEXINGTON
USS MILWAUKEE
USS NASHVILLE
USS AYLWIN
USS BIGELOW
USS DAHLGREN
USS DUPONT
USS MOUNT WHITNEY
USS PENSACOLA
USS SAMUEL GOMPERS
USS SIMON LAKE
USS TRENTON
USS VALDEZ
USS CHARLESTON
USS GUAM
USS KALAMAZOO
USS AUSTIN
USS KING
USS BIDDLE
USS BRUMBY
USS CLAUDE V RICKETTS
USS CONYNGHAM
USS DALE
USS DEWEY
USS ELMER MONTGOMERY
USS GLOVER
USS YELLOWSTONE
USS MOUNT BAKER
USS AMERICA
USS BELKNAP
USS BLANDY
USS DONALD B BEARY
USS EDWARD MCDONNELL
USS NASSAU
USS PONCE
USS SAVANNAH
USS ST LOUIS
USS TRUETT
USS WAINWRIGHT
USS DETROIT
USS IWO JIMA
USS L Y SPEAR
USS JONAS INGRAM
USS PORTLAND

PMS301(5)...ORIG FOR COMNAVSEASYSCOM WASH(18) 09221/15/1551
PMS301.16(1) 931(1) 941(1) 00(1) 99634(1) 52(1) 942(1)
05(1) 522(1) 05E(1) PMS373(1) 041(1) 0412(1)

0412(2)...INFO FOR CHNAVMAT WASHINGTON(9) 09221/ 1/0498
08B1(1) 0414(1) 09854(1) 048(2) 09A(1) 09B(1)

RTD:000-000/COPIES:0027

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CSN:VDTE00019 COMNAVSEASYSCO

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USS SAN DIEGO
USS SEATTLE
USS SYLVANIA
USS TALBOT
USS TRIPPE
USS WILLIAM V PRATT
USS FORRESTAL
USS INCHON
USS JOSEPHUS DANIELS
USS KIRK
USS MAHAN
USS MULLINNIX
USS RICHARD L PAGE
USS FRANK CABLE
USS MANLEY
USS PAUL
USS RICHARD E BYRD
USS SEMMES
COMCRUDESGRU TWO
COMDESRON TEN
COMPHIBGRU TWO
COMPHIBRON TWO
SUPSHIP BOSTON MA
COMDESRON TWO SIX
COMSERVGRU TWO
USS SIERRA
USS COME
USS PLYMOUTH ROCK
COMSERVRON TWO
COMSUBRON SIX
USS HAROLD J ELLISON
USS SPIEGEL GROVE
USNS PONCHATOULA
USS RALEIGH
USS CALOOSAHATCHEE
COMCARGRU SIX
USS SANTA BARBARA
USS SHREVEPORT
USS TARAWA
USS THOMAS C HART
USS VOGE
USS CANOPUS
USS GUADALCANAL
USS JOSEPH HEWES
USS JULIUS A FURER
USS LAWRENCE
USS MOINESTER
USS PHARRIS
USS SELLERS
USS MACDONOUGH
USS MILLER
USS PREBLE
USS SAMPSON
USS EMORY S LAND
COMDESRON FOURTEEN
COMDESRON TWO
COMPHIBRON SIX
COMDESRON FOUR
COMDESRON TWO FOUR
COMPHIBRON FOUR
COMSERVRON FOUR
USS YOSEMITE
USS MCCLOY
COMSUBRON SIX
COMDESRON TWO ZERO
USS VULCAN
USS HERMITAGE
USS VOGELGESANG
USS NITRO
USS STEINAKER
USS FORT SNELLING

UNCLAS //N09221//
SECTION 01 OF 02 //N09221//

SUBJ: EDTA BOILER WATERSIDE CLEANING METHOD, IMPLEMENTATION OF

A. NSTM S 9086 - GY - STM - 007/CH 221 BOILERS

1. SUMMARY: APPROVES THE USE OF EDTA FOR REMOVAL OF SOFT DEPOSITS FROM MAIN PROPULSION BOILERS IN FOSSIL FUEL FIRED STEAM SHIPS AND PROVIDES PROCEDURES AND SUPPORT INFORMATION FOR SAME.

2. AS PART OF THE STEAM PROPULSION PLANT IMPROVEMENT PROJECT, A LABOR SAVING ALTERNATIVE TO WIRE BRUSH AND WATERJET METHODS OF

713235/044 2 OF 9 MATA1902 044/15:19Z 122140Z FEB 81
CSN:VOTE00019 COMNAVSEASYSCO

BOILER WATERSIDE SOFT DEPOSIT REMOVAL HAS BEEN DEVELOPED AND IS HEREBY APPROVED FOR IMMEDIATE USE IAW THE PROCEDURES BELOW. THE METHOD INVOLVES TREATING THE BOILER WITH A SOLUTION OF EDTA PRIOR TO THE 1800 TO 2000 HOUR BOILER INSPECTION, STEAMING THE BOILER AT 240 PLUS OR MINUS 10 PSIG FOR FOUR HOURS, DUMPING AND FLUSHING THE BOILER AND THEN INSPECTING THE BOILER.

3. THERE ARE TWO APPROPRIATE STRENGTHS OF EDTA SOLUTION.
A. A TWO PERCENT SOLUTION IS USED FOR THE INITIAL CLEANING OF BOILER WITH EDTA TO ENSURE ANY EXCESSIVE DEPOSITS ARE REMOVED DURING THE FIRST CLEANING.
B. A ONE PERCENT EDTA SOLUTION, WHICH WILL REMOVE DEPOSITS THAT ARE NORMALLY FORMED DURING 2000 STEAMING HOURS, IS USED FOR ALL FOLLOW ON CLEANINGS.

4. MATERIALS REQUIRED:
A. EDTA (TETRASODIUM ETHYLENEDIAMINETETRAACETATE) HAMPENE 220, AVAILABLE FROM W.R. GRACE CO., OR VERSENE 220, AVAILABLE FROM DOW INTERNATIONAL. REQUIREMENTS IN POUNDS PER BOILER, BY SHIP ARE AS FOLLOWS:

POUNDS EDTA FOR ONE PERCENT SOLUTION	SHIPS
75	AD-14, AD-15, AD-17 THRU AD-19, AD-26, AD-36, FF-1098, AR-5 THRU AR-8, AVM-1, FF-1040, FF-1041, FF-1043 THRU FF-1045, FF-1047 THRU FF-1051, FFG-1 THRU FFG-6
100	AGF-3, CG-16 THRU CG-18, CG-26 THRU CG-34, DD-937, DD-933, DD-940 THRU DD-945, DD-948, DD-950, DD-951, DDG-2, DDG-3, DDG-7, DDG-8, DDG-10 THRU DDG-13, DDG-15 THRU DDG-22, DDG-31, DDG-33, DDG-34, DDG-40 THRU DDG-46, FF-1037, FF-1038, FF-1052 THRU FF-1097, LPD-1, LPD-2, LPD-4 THRU LPD-6, LSD-28 THRU LSD-35
125	AD-37, AD-41, AD-43, AD-38, AFS-1 THRU AFS-3, AGF-11, AS-51, AD-98, AD-99, AS-33, AS-34, CG-19 THRU CG-24, DD-714 THRU DD-890, DD-931, DD-933, DDG-4 THRU DDG-6, DDG-9, DDG-14, DDG-23, DDG-24, DDG-32, DDG-37 THRU DDG-39, LPD-7 THRU LPD-10, LPD-12 THRU LPD-15, LSD-37 THRU LSD-40
150	AE-21 THRU AE-29, AE-32 THRU AE-35, AFS-4 THRU AFS-7, AOR-1 THRU AOR-7, AS-36, AS-37, CV-41, CV-43, AVT-16, LCC-19, LCC-20, LPH-2, LPH-3, LPH-7, LPH-9 THRU LPH-12, LSD-36
175	AD-143 THRU AD-148, AOE-1 THRU AOE-3, CV-60, CV-61
200	AOE-4, CV-59, CV-62, CV-67, LKA-112
225	CV-63, CV-64, CV-66
250	LKA-113 THRU LKA-117, AD-177
275	LHA-1 THRU LHA-5

NOTE: THE ABOVE QUANTITIES ARE REQUIRED FOR A ONE PERCENT EDTA CLEANING. BOILERS BEING CLEANED FOR THE FIRST TIME WITH EDTA SHALL USE TWICE THE ABOVE QUANTITIES.
B. MIXING TANK WITH SPIGOT, AT LEAST 30 GAL, PLASTIC OR STEEL.

FABRICATE OR OBTAIN FROM CHEMICAL SUPPLY CO.
NOTE: EDTA SOLUTIONS REACT WITH ALUMINUM.
C. RUBBER OR PLASTIC HOSE (3/4 IN. I.D.) WITH HOSE CLAMPS TO REACH FROM MIXING TANK TO BOILER.
D. PORTABLE PUMP (MAY NOT BE REQUIRED, SEE PARA. 6.C.) EASTERN MAGNETIC DRIVE MD-80 AVAILABLE FROM FISHER SCIENTIFIC, CATALOG NO. 13-874-13.

5. THE POST CLEANING SOLUTION WILL RELEASE IRON OXIDE (RUST) WHEN EXPOSED TO AIR. TO AVOID CONTAMINATION OF BILGE WITH RUST, THE EDTA SOLUTION MUST BE DISPOSED OF IMMEDIATELY AFTER THE CLEANING. AT SEA THE SOLUTION MAY BE DUMPED OVERBOARD. IN PORT ARRANGE FOR DISPOSAL, CHECK LOCAL REQUIREMENTS (SLUDGE BARGE MAY BE REQUIRED). (SOLUTION WILL HAVE PH FROM 12.3 TO 12.5.)

6. PREPARATION:
A. BOILER TO BE CLEANED MUST BE AT ZERO PSIG.
B. PROVIDE FEEDWATER AT THE MIXING TANK.
C. CONNECT HOSING, MIXING TANK AND PUMP. THE HOSING, TANK AND PUMP SHALL BE FLUSHED WITH FEEDWATER PRIOR TO CONNECTING TO BOILER. IF MIXING TANK CAN BE LOCATED HIGHER THAN THE STEAM DRUM THE SOLUTION CAN BE GRAVITY FED.
D. CONNECT HOSING TO BOILER VENT. THIS CONNECTION MAY REQUIRE REMOVING A VALVE AND PREPARING A FLANGED INLET PIPE.
E. IF BOILER IS EMPTY, FILL WITH FEEDWATER TO BOTTOM OF GAGE GLASS, DO NOT TREAT. IF BOILER IS FILLED AND TREATED, DO NOT DUMP. ADJUST BOILER WATER LEVEL TO THE BOTTOM OF GAGE GLASS. CLEANING WITH EDTA CAN BE ACCOMPLISHED WITH OR WITHOUT CHEMICALS IN BOILER WATER.

7. CLEANING PROCEDURE:
A. ADD FEEDWATER TO THE MIXING TANK.
B. ADD EDTA TO THE FEEDWATER BY MIXING 50 LBS EDTA WITH 25 GAL FEEDWATER. MIX WITH WOODEN STIRRER.
WARNING: EDTA FORMS AN ALKALINE SOLUTION. PERSONNEL MIXING SOLUTION SHALL WEAR RUBBER GLOVES, RUBBER APRON, SAFETY GOGGLES AND DUST MASK. IF SOLUTION IS SPLASHED IN EYES OR ON SKIN WASH WITH COPIOUS AMOUNTS OF WATER. FOR EYES ALSO SEEK MEDICAL ATTENTION IMMEDIATELY.
C. PUMP OR GRAVITY DRAIN SOLUTION INTO THE BOILER. SUPERHEATER DRAIN SHOULD BE OPEN TO ALLOW FOR PRESSURE RELEASE.
D. REPEAT INJECTIONS UNTIL THE AMOUNT INDICATED IN PARA. 4.A. IS INJECTED.
E. FLUSH TANK, HOSES, AND PUMP WITH FEEDWATER.
F. DISASSEMBLE INJECTION EQUIPMENT. PREPARE BOLIER FOR STEAMING.
G. THE FOLLOWING STEAMING PROCEDURE SHALL BE FOLLOWED:
(1) WHEN OTHER BOILER(S) IN THE SPACE IS (ARE) SECURED:
(A) LIGHT OFF ACCORDIN TO EOSS/SHIPS LIGHT OFF CHECK LIST EXCEPT:
1. SHIPS EQUIPPED WITH NAVJET AND RACER BURNERS SHALL USE SPRAYER PLATE 4-51-57-55-80, NSN 9C 4520-01-069-3261

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CSN:VDTE00019 COMNAVSEASYSCD

THROUGHTOUT THE CLEANING.

2. SHIPS EQUIPPED WITH WALLSEND BURNERS SHALL USE SPRAYER PLATE 5X-80-43-43-78 NSN 9C 4530-01-047-0608 THROUGHTOUT THE CLEANING.

3. SHIPS EQUIPPED WITH STRAIGHT MECHANICAL, RETURN FLOW, AND VARIABLE STEAM PRESSURE BURNERS SHALL USE THE LIGHT

BT

ROUTINE

R 122140Z FEB 81

FM COMNAVSEASYSCOM WASHINGTON DC

SUBJ: EDTA BOILER WATERSIDE CLEANING METHOD, IMPLEMENTATION OF

TO USS BROOKE	USS BRENTON
USS PATTERSON	AIG 373
XMT USS AINSWORTH	USS BIDDLE
USS BARRY	USS BRUMBY
USS CAPODANNO	USS CLAUDE V RICKETTS
USS CONNOLE	USS CONYNGHAM
USS COONTZ	USS DALE
USS DAVIS	USS DEWEY
USS EDSON	USS ELMER MONTGOMERY
USS FORREST SHERMAN	USS GLOVER
USS LEXINGTON	USS YELLOWSTONE
USS MILWAUKEE	USS MOUNT BAKER
USS NASHVILLE	USS AMERICA
USS AYLWIN	USS BELKNAP
USS BIGELOW	USS BLANDY
USS DAHLGREN	USS DONALD B BEARY
USS DUPONT	USS EDWARD MCDONNELL
USS MOUNT WHITNEY	USS NASSAU
USS PENSACOLA	USS PONCE
USS SAMUEL GOMPERS	USS SAVANNAH
USS SIMON LAKE	USS ST LOUIS
USS TRENTON	USS TRUETT
USS VALDEZ	USS WAINWRIGHT
USS CHARLESTON	USS DETROIT
USS GUAM	USS IWO JIMA
USS KALAMAZOO	USS L Y SPEAR
USS AUSTIN	USS JONAS INGRAM
USS KING	USS PORTLAND

~~5222(2)...INFO FOR COMNAVSEASYSCOM WASH(17)~~ 09221/ 1/1551
~~05R(1) 04(1) 0711(1) 08(1) 99634(1) 93(1) 94(1) PM2(1) PMS301(1)~~
~~PMS392(1) 0562(1) 04C(1) 520(1) 05(1) 00(1)~~

0412(2)...INFO FOR CHNAVMAT WASHINGTON(9) 09221/ 1/0498
0081(1) 0414(1) 09854(1) 048(2) 09A(1) 098(1)

RTD:000-000/COPIES:0026

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CSN:VDTE00019 COMNAVSEASYSCO

USS SAN DIEGO
USS SEATTLE
USS SYLVANIA
USS TALBOT
USS TRIPPE
USS WILLIAM V PRATT
USS FORRESTAL
USS INCHON
USS JOSEPHUS DANIELS
USS KIRK
USS MAHAN
USS MULLINNIX
USS RICHARD L PAGE
USS FRANK CABLE
USS MANLEY
USS PAUL
USS RICHARD E BYRD
USS SEMMES
COMCRUDESGRU TWO
COMDESRON TEN
COMPHIBGRU TWO
COMPHIBRON TWO
SUPSHIP BOSTON MA
COMDESRON TWO SIX
COMSERVGRU TWO
USS SIERRA
USS CONE
USS PLYMOUTH ROCK
COMSERVRON TWO
COMSUBRON SIX
USS HAROLD J ELLISON
USS SPIEGEL GROVE
USNS PONCHATOULA
USS RALEIGH
USS CALOOSAHATCHEE
COMCARGRU SIX
USS SANTA BARBARA
USS SHREVEPORT
USS TARAWA
USS THOMAS C HART
USS VOGE
USS CANOPUS
USS GUADALCANAL
USS JOSEPH HEWES
USS JULIUS A FURER
USS LAWRENCE
USS MOINESTER
USS PHARRIS
USS SELLERS
USS MACDONOUGH
USS MILLER
USS PREBLE
USS SAMPSON
USS EMORY S LAND
COMDESRON FOURTEEN
COMDESRON TWO
COMPHIBRON SIX
COMDESRON FOUR
COMDESRON TWO FOUR
COMPHIBRON FOUR
COMSERVRON FOUR
USS YOSEMITE
USS MCCLOY
COMSUBRON SIX
COMDESRON TWO ZERO
USS VULCAN
USS HERMITAGE
USS VOGELGESANG
USS NITRO
USS STEINAKER
USS FORT SNELLING

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FINAL SECTION OF 02 //N09221//

OFF PLATE THROUGHTOUT THE CLEANING.
(B) STARTING THE MAIN FEED PUMP MAY REQUIRE OPENING THE OVERLOAD NOZZLES AND MANUALLY JACKING OPEN THE GOVENOR VALVE. THE MAIN STEAM STOP MUST BE OPEN. DO NOT OPERATE THE FEED PUMP ON BYPASS. LEAVE THE OVERLOAD NOZZLES OPEN TO TAKE SOME OF THE STEAM LOAD AND PROVIDE MAX PUMP DISCHARGE PRESSURE. IF MAIN FEED PUMP OPERATION IS NOT POSSIBLE, USE EMERGENCY FEED PUMP FOR THIS OPERATION.
(C) BLEED STEAM TO AUXILIARY EXHAUST. THE ATMOSPHER DUMP VALVE WILL EVENTUALLY OPEN.

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CSN:NOTE00019 COMNAVSEASYSCO

(D) ADJUST OIL PRESSURE AND/OR BLEED STEAM TO MAINTAIN 240 PLUS OR MINUS 10 PSI STEAM DRUM PRESSURE. OPEN SUPERHEATER DRAINS IF REQUIRED TO MAINTAIN STEAM DRUM PRESSURE. DO NOT EXCEED 250 PSI. SECURING OF ONE BURNER MAY BE REQUIRED IN SHIPS EQUIPPED WITH PRESSURE FIRED BOILERS.

(E) FEED WATER TO BOILER AS REQUIRED TO MAINTAIN NORMAL WATER LEVEL.

(F) THE CLEANING SOLUTION WILL GIVE OFF A VOLATILE COMPONENT DURING THE FIRST HOUR OF CLEANING. THIS WILL CAUSE AN INCREASE IN THE SALINITY INDICATOR READINGS WHERE THE STEAM IS USED, HOWEVER NO HARMFUL EFFECTS WILL OCCUR.

(2) WHEN OTHER BOILER(S) IN THE SPACE IS (ARE) ON THE LINE THE ABOVE PROCEDURES APPLY EXCEPT FOR THE FOLLOWING:

(A) STEAM STOPS AND BYPASS VALVES ON THE BOILER BEING CLEANED CANNOT BE OPENED.

(B) THE BOILER PRESSURE WILL BE CONTROLLED BY ADJUSTING FIRING RATE, NORMAL BLEED OFF TO AUX EXHAUST, AND OPENING SUPERHEATER VENTS AND DRAINS.

H. SECURE BOILER 4 HOURS AFTER REACHING 240 PSIG.

I. DUMP THE HOT CLEANING SOLUTION WHILE UNDER SLIGHT PRESSURE. THE CLEANING SOLUTION WILL RELEASE IRON OXIDE (RUST) WHEN EXPOSED TO AIR. PUMP BILGES OVERBOARD WHEN CLEANING AT SEA. IF CLEANING IN PORT DISPOSE OF IN ACCORDANCE WITH LOCAL REQUIREMENTS FOR 12.3-12.5 PH WATER.

J. THROUGHLY FLUSH THE BOILER BY FILLING AND DUMPING AT LEAST TWICE WITH FEEDWATER.

K. OPEN AND INSPECT IAW PARA 221-2.111 OF REF A EXCEPT THAT ONLY REMOVAL OF ONE GIRTH PLATE VICE ALL STEAM DRUM INTERNALS IS REQUIRED TO INSPECT UPPER END OF SCREEN WALL TUBES. TUBES SHOULD APPEAR BLACK WITHOUT SOFT DEPOSITS AND A LIGHT DUST LIKE POWDER MAY BE PRESENT. REMOVE ANY LOOSE DEPOSITS THAT HAVE ACCUMULATED.IF THE INSPECTION RESULTS INDICATE THE CLEANING WAS NOT SUCCESSFUL THE BOILER MUST BE RECLEANED USING CLEANING METHOD DEPENDING ON CONDITIONS NOTED. INSPECTION BY CERTIFIED SCPI IS RECOMMENDED PRIOR TO RECLEANING.

8. FOLLOWING EDTA CLEANING A FRESHLY FILLED BOILER WILL SHOW SOME RESIDUAL PH. WHEN THE BOILER IS FRESHLY FILLED FOR THE FIRST TIME, FOLLOWING THE EDTA CLEANING, THE BOILER WATER SHALL BE SAMPLED PRIOR TO LIGHT OFF AND TESTED FOR PH. ADJUST THE INITIAL TSP DOSAGE ACCORDINGLY.

9.THE BOILER WILL REQUIRE ADDITIONAL BLOWDOWNS DURING THE FIRST 168 STEAMING HOURS FOLLOWING AN EDTA CLEANING. CONDUCT A 10 PERCENT SURFACE BLOWDOWN EVERY 24 HOURS. A BOTTOM BLOWDOWN SHALL BE PERFORMED AT LEAST EVERY 72 HOURS, AND PREFERABLY EVERY 48 HOURS IF POSSIBLE.

10.THE MECHANICAL CLEANING HOURS ARE TO BE ZEROED IF THE INSPECTION SHOWS THE CLEANING WAS SUCCESSFUL. THE CHEMICAL CLEANING HOURS ARE

NOT ZEROED SINCE COMPLETE REMOVAL OF HARD DEPOSITS IS NOT ACHIEVED BY THE EDTA PROCEDURE. EDTA CLEANING IS NOT CONSIDERED AN ALTERNATIVE TO ACID CLEANING.

11. USE OF EDTA CLEANING PROCEDURE WILL BE INCLUDED IN THE NEXT CHANGE TO REF A. PMS WILL BE UPDATED ACCORDINGLY.

12. DRAFT AEL COVERING THE EDTA CLEANING METHOD HAS BEEN FORWARDED TO SPCC MECHANICSBURG AND IS EXPECTED TO BE ISSUED BY APRIL 1981. STOCK SYSTEM SUPPORT IS SCHEDULED FOR JUNE 1981. NAVSEA WILL ADVISE WHEN STOCK SYSTEM SUPPORT IS AVAILABLE. IN THE INTERIM, UNTIL STOCK SYSTEM SUPPORT IS AVAILABLE LOCAL PURCHASE FROM SOURCES GIVEN IN PARA. 4. ABOVE IS AUTHORIZED.

BT

ROUTINE

R 110353Z MAR 81

FM COMNAVSEASYSCOM WASHINGTON DC

SUBJ: EDTA BOILER WATERSIDE CLEANING

TO COMNAVSURFPAC SAN DIEGO CA

INFO SPCC MECHANICSBURG PA
COMNAVSURFLANT NORFOLK VA
COMSUBLANT NORFOLK VA
NAVSSES PHILADELPHIA PA
COMNAVAIRPAC SAN DIEGO CA
COMNAVAIRLANT NORFOLK VA
COMSUBPAC PEARL HARBOR HI

UNCLAS //N09221//

SUBJ: EDTA BOILER WATERSIDE CLEANING

A. COMNAVSURFPAC SAN DIEGO CA 251855Z FEB 81 NOTAL
B. COMNAVSEASYSCOM WASHINGTON DC 122140Z FEB 81
C. NSTM S9086-GY-STM-007/CH 221 BOILERS

1. SUMMARY: THIS MESSAGE PROVIDES ADDITIONAL INFORMATION REGARDING EDTA BOILER CLEANING PROCEDURES.

2. REF A INDICATED IMPLEMENTATION OF SUBJ CLEANING METHOD AUTHORIZED BY REF B IS BEING HELD IN ABEYANCE PENDING RESOLUTION OF SEVERAL QUESTIONS/CONCERNS.

3. AS INDICATED REF B THE EDTA CLEANING METHOD WAS DEVELOPED AS A LESS LABOR INTENSIVE ALTERNATIVE TO THE PRESENT MECHANICAL METHODS (WATER JET, WIRE BRUSH) FOR REMOVAL OF SOFT DEPOSITS FROM BOILER WATERSIDES. REF C REQUIRES OPENING AND INSPECTING EACH BOILER EVERY 1800 TO 2000 STEAMING HOURS AND CLEANING THE BOILER IF REQUIRED, USING THE CLEANING METHOD DICTATED BY THE CONDITIONS FOUND (E.G. MECHANICAL FOR SOFT DEPOSITS AND ACID FOR HARD DEPOSITS). REF B DOES NOT CHANGE THE REF C REQUIREMENT. EXPERIENCE INDICATES THAT MOST BOILERS REQUIRE MECHANICAL CLEANING EVERY 1800 TO 2000 HOURS. ACCORDINGLY REF B AUTHORIZED THE USE OF EDTA CLEANING AFTER 1800 TO 2000 HOURS OF STEAMING AND PRIOR TO THE 1800 TO 2000 HOUR INSPEC-

PMS301(5)...ORIG FOR COMNAVSEASYSCOM WASH(11) /13/
PMS301.16(1) 05(1) 00(1) 99634(1) 52(1) 522(1)

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CSN:OCB 00174 COMNAVSEASYSCO

TION. AS INDICATED REF 8, IF THE INSPECTION INDICATES THE EDTA CLEANING WAS NOT SUCCESSFUL, THE BOILER MUST BE RECLEANED USING THE CLEANING METHODS DICTATED BY THE CONDITIONS NOTED. THIS DOES NOT PRECLUDE THE POSSIBILITY OF BACK TO BACK EDTA CLEANINGS WHERE ONLY SMALL AMOUNTS OF SOFT DEPOSITS REMAIN. IT IS EXPECTED THAT THE PRESCRIBED CONCENTRATION OF EDTA CLEANING SOLUTION WILL COMPLETELY CLEAN MOST BOILERS. FAILURE TO ACHIEVE COMPLETE CLEANING IS INDICATIVE OF A POTENTIALLY SERIOUS PROBLEM (HARD SCALE, BOILER WATER CONTAMINATION) THAT SHOULD BE EVALUATED BY A CERTIFIED SGPI. CLEANING METHOD TO BE USED IS DEPENDENT ON CONDITIONS.

4. REF B SPECIFIED THE USE OF HAMPENE 220 OR VERSENE 220 FOR THE EDTA CLEANING PROCESS. NO SUBSTITUTION IS AUTHORIZED. STOCK SYSTEM AVAILABILITY SCHEDULED FOR JUNE 18. IN INTERIM, FOR LOCAL PROCUREMENT INFORMATION, CONTACT THE FOLLOWING:

A. FOR HAMPENE 220 CALL ORGANIC CHEMICAL W.R. GRACE AND CO:
EAST COAST (201) 635-6305
WEST COAST (415) 568-3427

B. FOR VERSENE 220 CALL DEBRA GOLDSBE (DOW CHEMICAL) AREA CODE (201) 845-5000 EXT 248.

5. THE CLEANING SOLUTION SHOULD BE DUMPED AS SOON AS PRESSURE HAS BEEN REDUCED TO A MINIMUM INDICATION ON STEAM PRESSURE GAGE, THE BOILER HAS BEEN VENTED AND NO STEAM IS FORMING. DO NOT ALLOW THE SOLUTION TO COOL TO AMBIENT TEMP.

6. EDTA CLEANING SOLUTION CAN BE NEUTRALIZED AND DISPOSED OF BY LOCAL PUBLIC WORK CENTERS (PWC)/ENGINEERING FIELD DIVISION (EFD) IAW THE CONSOLIDATED HAZARDOUS ITEM LIST (CHIL). NAVSEA PMS301 IS CURRENTLY WORKING ON NEUTRALIZATION PROCEDURES SUITABLE FOR SHIPBOARD USE. WILL ADVISE.

7. EDTA SHOULD BE STORED IN A COOL, DRY AREA AWAY FROM ACIDS AND STRONG REDUCING AGENTS. THESE REQUIREMENTS ARE SAME AS THOSE FOR TRISODIUM PHOSPHATE.

8. THE EDTA CLEANING METHOD WILL RESULT IN A MAJOR REDUCTION OF SHIPS FORCE MAN HOURS REQUIRED TO CLEAN BOILER WATERSIDES. EDTA CLEANING WAS AUTHORIZED PRIOR TO HAVING SUPPLY SYSTEM SUPPORT IN PLACE IN ORDER TO PERMIT THE SHIPS THAT REQUIRE BOILER WATERSIDES CLEANING BEFORE JUN 81 TO REALIZE THAT LABOR SAVINGS. DEFERRAL OF IMPLEMENTATION IS NOT RECOMMENDED.

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CSH:JCB 00174 COMNAVSEASYSCO

APPENDIX F

SOURCES OF INFORMATION

The specific sources of information used as the basis for this analysis are as follows:

1. Generation IV MDS narrative and part data for the AFS-1, AOE-1, and AOR-1 Class ships for the period 1 January 1971 through 30 June 1980; and for the AO-177 Class ships for the period 1 January 1981 through 31 July 1981.
2. CASREPs for the AFS-1, AOE-1, and AOR-1 Class ships for the period 1 January 1977 through 30 June 1980; and for the AO-177 Class ships for the period 1 January 1981 through 30 June 1981.
3. Naval Sea Support Center Pacific, *Planned Maintenance System Automated List of Effective Pages (PMS-5)*, GFR-3-80, dated July 19, 1980.
4. NSTM Chapter 220, Volumes I and II, *Boiler Water/Feedwater Water Chemistry* and *Boiler Water/Feedwater Test and Treatment*, respectively, dated 1 January 1977.
5. NSTM Chapter 221, "Boilers," dated 15 September 1979.
6. NAVSEA S9221-AE-MMO-010/Type V2M (Volumes I and II), technical manual for Combustion Engineering, Inc., boilers installed on AOE-1 through -3, dated 15 October 1978.
7. NAVSHIPS 0951-017-0010, technical manual for Babcock and Wilcox boilers installed on AOE-4, dated July 1969.
8. NAVSHIPS 0951-006-6010, technical manual for Babcock and Wilcox boilers installed on AFS-1 through -3, dated April 1967.
9. NAVSHIPS 0951-016-0010 and 0951-016-0020, technical manuals for Babcock and Wilcox boilers installed on AFS-4 through -7, dated June 1968.
10. NAVSHIPS 0951-018-0010, technical manual for Foster-Wheeler boilers installed on AOR-1 through -7, dated 8 May 1970.
11. System Maintenance Analysis Reports:
    - *FF-1052 Class Propulsion Boiler System*, ARINC Research Publication 1646-03-6-1589, March 1977.
    - *DDG-37 Class Main Propulsion Boilers*, ARINC Research Publication 1652-03-15-1752, May 1978.

- *CG-16 and CG-26 Class 1200 PSI Propulsion Plant, SWAB Group 200,* ARINC Research Publication 1671-04-3-2119, November 1979.

12. Ship Alteration and Repair Packages (SARPs):
    - AFS-1 dated 4/11/77
    - AFS-2 dated 5/8/80
    - AFS-3 dated 12/20/78
    - AFS-4 dated 12/21/79
    - AFS-5 dated 7/12/78
    - AFS-6 dated 7/12/78
    - AFS-7 dated 11/15/79
    - AOE-1 dated 10/5/79
    - AOE-2 dated 9/22/76
    - AOE-3 dated 12/26/78
    - AOE-4 dated 1976
    - AOR-1 dated 11/16/78
    - AOR-2 undated
    - AOR-3 dated 6/15/79
    - AOR-4 dated 9/26/80
    - AOR-5 dated 1/5/77
    - AOR-6 dated 4/78

    No SARP was provided for AOR-7, and there have been no overhauls for AO-177 Class ships.

13. Results of ARINC Research Corporation visits to AOE-4 (USS DETROIT), 11 May 1981; COMNAVSURFLANT Code N4111, NAVSEACENLANT DET Code 710 and AFS-6 (USS SAN DIEGO), 20-22 May 1981; AO-177 (USS CIMARRON), 27 October 1981; PMS-383A, 2 December 1981; PMS-301, 17 December 1981; and AO-178 (USS MONONGAHELA), 21 January 1982.

14. Steam Propulsion Plant Improvement Program ShipAlt documentation: Table I.b -- ShipAlt Listing by Ship Type/Class, January 1981; Table III -- Ship Summary Status, 4 April 1981.

15. COMNAVSURFLANT and COMNAVSURFPAC Type Commander's Coordinated Shipboard Allowance Lists (COSALs), dated 24 April 1979 and 25 June 1979, respectively.

16. Shipalt briefs and SAMIS shipalt information for AFS-1, AOE-1, AOR-1, and AO-177 Class 600 psi boilers and boiler accessory equipments.

17. Maintenance index pages (MIPs) and maintenance requirement cards (MRCs) for the AFS-1, AOE-1, AOR-1, and AO-177 Class 600 psi boilers.

18. Allowance parts lists (APLs) for selected components of the AFS-1, AOE-1, AOR-1, and AO-177 Class 600 psi boilers and accessory equipments.

19. OPNAVINST 4780.4, *Material Maintenance Management (3M) Manual*, Volumes I, II, and III, June 1973.

20. Common Configuration Class List for AOE-1, AFS-1, AD-14, AO-177, AOR-1, and AE-26 Class Ships, 11 August 1980.

21. NAVSHIPS S9221-A2-MMA-010/AO-177, Technical Manual for Combustion Engineering Boilers Installed on AO-177 Class Ships, dated 1 December 1979.

22. NAVSEA S9A00-FM-POG-010/AO-177, *Propulsion Operating Guide for AO-177 Class Fleet Oilers*, undated.

23. NAVSEA S9A00-FM-TAB-010/AO-177 Class, *Training Aid Booklet Volume 1, Piping Systems, AO-177*, undated.

24. Route sheet and office memo, originated by NAVSEA 941 on 16 November 1981, with comments by NAVSEA 522, dated 23 November 1981.

25. NAVSSES letter [022E:WL:mea; 9221 (OM-0576); Ser 078; 25 February 1982] to PERA (CSS).

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